VOLUME 30 NUMBER 2

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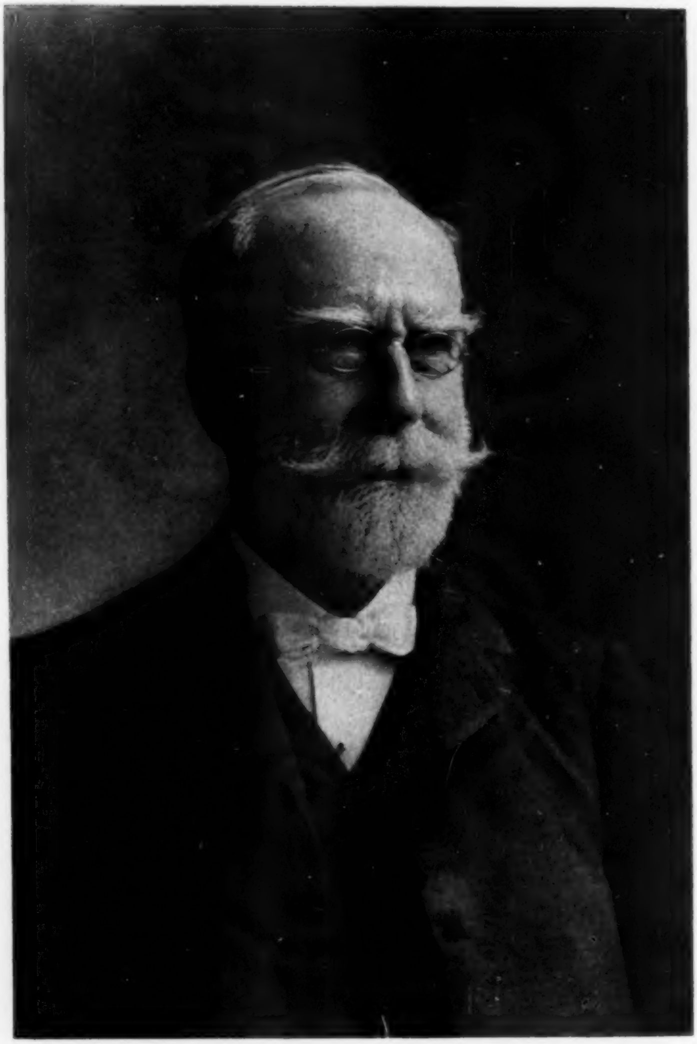

Coleman Sellers

PAST-PRESIDENT

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

FEBRUARY 1908 VOL. 30 No. 2

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PROCEEDINGS

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PROCEEDINGS

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 30 FEBRUARY 1908 NUMBER 2

AT a recent meeting of the Council, very important action was taken in approving the report of the Committee on Affiliated Societies.

The committee, composed of Professor Hutton, Prof. R. H. Fernald, Dr. A. C. Humphreys, Mr. F. W. Taylor and Mr. H. H. Suplee, has held several protracted sessions which have been devoted to careful consideration and the safeguarding of the interests of all concerned and at the same time affording the principle of home rule so essential to the life of a section.

As the guests of the committee, the confrères of the proposed Gas Power Engineering Section and the Society's standing Committee on Meetings gave careful consideration to the subject and all are to be congratulated on the results. The following resolutions were adopted:

REPORT OF COMMITTEE ON AFFILIATED SOCIETIES

To the Council of the American Society of Mechanical Engineers:

The committee appointed to consider and report upon rules for professional sections, with special reference to the organization of a Gas Power Section, and to suggest rules for the affiliation of bodies which could not form sections, present their report in two parts:

Part I. Professional Sections

It is the opinion of the committee that the best interests of professional sections will be secured by a form of broad local self govern-

ment, in such bodies: It recommends therefore that the Council pass the following fundamental resolutions:

A *Resolved,* That the Council add to the rules heretofore enacted and published for the guidance of the organization of sections, in paper 1095, vol. 27 of the Transactions, the word "local" (in the sense of geographical used in C52) after the first word and wherever it occurs in those rules, so as to read "a local section," etc.

B *Resolved,* That the Council adopt the following rules for the organization and conduct of professional sections, or those which specialize in the direction of certain topics.

a A professional section of the Society shall consist of Honorary Members, Members, Associates, and Juniors of The American Society of Mechanical Engineers and of other persons to be designated Affiliates as hereinafter described.

b A professional section of The American Society of Mechanical Engineers may, with the approval of the Council, be organized for the consideration of any engineering, scientific, or professional topic, provided that a number satisfactory to the Council, of members of The American Society of Mechanical Engineers, unite in making written request for such an organization. Such section shall be designated as —— Section of The American Society of Mechanical Engineers—the blank being filled by the topic specialized.

c The provisions of the Constitution, By-Laws, and Rules of The American Society of Mechanical Engineers, and the precedents of the Society with respect to professional sessions for the discussions of papers shall cover the procedure of the professional sections, except that no meeting of a section shall be considered a meeting of the Society as a whole.

d For the convenient conduct of its professional affairs, the section shall organize an Executive Committee of five members of the Society, under the general direction of Council. Such officers as the section shall require, must be selected from the membership of the Society. Other committees of the section shall be appointed by its Executive Committee.

e The Executive Committee of the section, subject to the approval and direction of the Secretary of the Society,

shall designate a Secretary of the section, whose duties shall be those usually attaching to the Secretary of a professional session and who shall also see that the discussions of papers are satisfactorily reported and transmitted to the Secretary of the Society.

f Expenditures for the purposes of the section chargeable to the Society shall be authorized by the Secretary of the Society before they are incurred, and must be provided for in the estimate and budget of the Committee on Meetings. No liability otherwise incurred shall be binding on the Society. Any expenditure not so provided shall be met by the section itself.

g Engineers and others not members of the American Society, but desiring to participate in meetings of the section, may enroll themselves as affiliates as heretofore provided with the approval of the Executive Committee of the section. Such affiliates shall have the privilege of presenting papers and taking part in the discussions. They shall pay $5 per annum which shall be due and payable, in advance, on October 1 of each year of their enrollment, and shall thereby be entitled to receive the Proceedings of the Society as they are issued month by month, for a period covered by their dues.

h The Council of The American Society of Mechanical Engineers may, at 60 days notice, suspend or disband any section.

The foregoing resolutions are intended as a helpful system of organization only, and the Council has no desire to interfere with the development of a section, but on the other hand, to encourage the initiative action.

Notice of the adoption of these matters has been sent to the Secretary of the temporary organization and it is confidently hoped that the section will soon be officially formed.

Every inducement in the shape of facilities for holding the meetings, and as often as they choose, of the Society's office organization for doing printing at less cost than any separate society can possibly do it, is offered those members of the Society who desire to form sections and to specialize in any branch of engineering.

It is felt that if at a previous time this same opportunity had been possible, The Societies of Testing Materials, The Heating and Ventilating Engineers, The American Society of Refrigerating Engineers,

etc., would not only not have been obliged to form separate societies, but as sections of this Society they would today be able to conduct their activities with at least *equal* satisfaction to themselves and presumably more, for the reason that they would be carried on at less expense.

DETROIT CONVENTION

All those who attended the convention in Detroit in 1895, will surely go this year, as that was a meeting long to be remembered with pleasure. To those who have not decided to go, let it be said that the Committee on Arrangements, just chosen, do not propose that the 1908 Detroit Convention will be any less delightful.

On January 16, the members of the Society in and about Detroit informally convened and chose a local committee as follows: Alex. Dow, Chairman W. J. Keep, W. S. Russell, F. E. Kirby, G. A. Herbert, T. H. Hinchman, Jr., and H. E. Coffin.

Many of Detroit's attractions, such as her beautiful parks and various industries, will be visited, and excursions on the river are planned.

A most cordial reception was given the Secretary, Mr. Calvin W. Rice, who in response told of the forward work of the Society which the Council had just sanctioned.

One of the subjects which will be exhaustively treated at the coming convention will be the conveying of materials, now so important in all manufacture.

FEBRUARY MEETING

The date of the regular monthly meeting of the Society, February 11, 1908, we are pleased to announce will be assumed by the Gas Power Section.

Not only members of the Society but all Engineers interested in the subject, whether members or not, are not only welcome but may enroll themselves as affiliates of the section and participate in the deliberations of a section.

The following topics will be discussed and a very interesting meeting is promised:

Experimental Gas Turbines in France (with lantern slides).

A Simple Continuous Gas Calorimeter.

A Gas Engine and Producer Guarantee.

MARCH MEETING

The March meeting of the Society will be held on the second Tuesday of March. Dr. C. P. Steinmetz, Past President of The American Institute of Electrical Engineers and Professor of Electrical Engineering at Union University, will present a paper on "The Theory of the Steam Passage of the Steam Turbine."

THE JANUARY MONTHLY MEETING

The January Meeting of the Society, held as usual on the second Tuesday evening of the month, was given over to papers and discussions on Car Lighting.

The principal address was by Mr. R. M. Dixon, President of the Safety Car Lighting and Heating Company. It was discussed by Mr. George R. Henderson, Mr. H. K. Brooks, Mr. Lamar Lyndon, Mr. B. P. Flory, Mr. R. E. Bruckner, Mr. W. E. Ver Planck, Mr. W. D. Young and Mr. George L. Fowler.

UNITED ENGINEERING SOCIETY

Prof. F. R. Hutton, Past President of the Society, has been chosen a Trustee of The United Engineering Society. The term of office is three years.

PHOTOGRAVURES OF PAST PRESIDENTS OF THE SOCIETY

The Society expects to issue in Proceedings from time to time, photogravures of Past Presidents and Honorary Members.

As these may be desired in a larger size, suitable for framing, the Society will undertake to have prints of each plate made. Orders for these photogravures will be filled for about fifty cents each, mounted on best quality of plate paper, in sizes 8 by 12.

BOOKLETS ON HUDSON COMPANIES' TUNNELS AND COLOR PHOTOGRAPHY

Members attending the Annual Meeting of the Society will recall the article on "The Tunnels of the Hudson Companies" specially

prepared for the excursion of the Society through the McAdoo Tunnel, and also the booklet on Color Photography by Mr. H. F. J. Porter, member, which was published by the Society and distributed at the lecture on Color Photography.

Extra copies can be obtained upon request.

HONORARY VICE-PRESIDENTS

Mr. James M. Dodge and Mr. Fred. W. Taylor, Past Presidents of the Society, were appointed Honorary Vice-Presidents to represent the Society at the funeral of Mr. Coleman Sellers, Past President, which was held in Philadelphia, December 30, 1970.

BOOKS FOR THE LIBRARY

Members are invited to donate copies of their works to the Library. This is a custom generally followed by members of an association, and in the case of this Society, with its wide membership among technical writers, its observance would result in a considerable development of the up to date resources of the library.

DISCUSSION

The discussion on Gas Power has been selected for this issue of Proceedings as it has been thought advisable to bring together, as far as possible, in one issue the contributions on one subject.

Discussion on Foundry Practice, Superheated Steam and miscellaneous subjects will be published in the March number.

FORWARD WORK IN THE PROCEEDINGS

The Committee on Advertising, Mr. G. M. Basford, Prof. F. R. Hutton, and the Secretary, made a report to the Council on the matter of developing the publications of the Society so that they would meet the various wants of our membership.

In brief, this proposition includes the employment of an editor of national reputation and one who is in sympathy with the ideals of the Society.

To meet the additional expense for such an editorial department it is proposed to receive a restricted and limited amount of advertising.

It is obvious that the membership in an engineering society is a very select body of men before whom to advertise, and it will be immediately valuable to a number of advertisers to place before them claims to their patronage.

The development of the Proceedings, made possible by the increased income, will, we are sure, appeal to those who do not approve of receiving advertisements in the Society's publications. It is confidently hoped that the circulation will increase with the improved quality and variety of the matter presented.

These two large movements are considered epochs in the Society's history.

MEMORIAL EXERCISES IN HONOR OF LORD KELVIN

One of the most impressive exercises ever held in the Engineering Societies' building was the memorial service on Sunday, January 12, in honor of the late Sir William Thomson, Baron Kelvin, under the auspices of The American Institute of Electrical Engineers, of which Lord Kelvin was an Honorary Member.

This Society, in company with other Engineering and Scientific Societies, participated, and at the invitation of the Council, it was officially represented by the following members: Rear Admiral Melville, Mr. Andrew Carnegie, Mr. B. F. Isherwood, Mr. George Westinghouse and Mr. Thomas A. Edison,

Rear Admiral Melville, who was one of the speakers, gave an account of Lord Kelvin's work in relation to the navy.

Dr. Manning of Trinity Church spoke of the beautiful life of Lord Kelvin and pointed to him as an example of a Christian who had found his researches in science an aid to his religion, and particularly mentioned that in life and in death he had affirmed his unfailing faith in a living God.

Prof. Elihu Thomson spoke of the relation of Lord Kelvin to electrical engineering, mentioning his inventions of measuring instruments, his participation in the determination of the C. G. S. system, and in the electrical development of Niagara.

Mr. George G. Ward, Honorary Secretary of The American Institute of Electrical Engineers, spoke of Lord Kelvin's part in the laying of the first Atlantic cable, and of his invention of the siphon recorder, which made its operation so successful.

Mr. T. C. Martin, editor of the Electrical World, gave an account of

Lord Kelvin's interest in the formation of The American Institute of Electrical Engineers.

Prof. E. L. Nichols, President of the American Association for the Advancement of Science, gave a most complete address on the work of Lord Kelvin in all branches of science, and together with all those who spoke on this occasion, pronounced him the greatest man of science in this generation.

WATT AND FULTON RELICS IN THE POSSESSION OF THE SOCIETY

Through the kindness of Mr. H. H. Suplee, editor of Cassier's Magazine and member of the Society, we are able to show in this issue of Proceedings reproductions of very interesting relics which have recently been placed in the custody of the Society.

Fig. 1 shows a copper plate impression of the Certificate of Membership in the Insurance Society of the Soho Manufactory of Boulton and Watt at Birmingham. This certificate, together with two other impressions, was found in Heathfield Hall, in the room in which James Watt did his private experimental work. It was found by Mr. George Tangye in 1903, sealed with the seal of James Watt. Mr. Tangye sent the certificate to Prof. John E. Sweet, who now transfers it to this Society as being a logical depository for such relics.

Fig. 2 shows the interior of James Watt's work room in Heathfield Hall in which the package was found. The room was allowed by Mr. Tangye, the subsequent owner, to remain exactly as Watt left it.

Attention is directed to portions here shown of the carving and duplicating machine upon which Watt was engaged at the time of his death, in 1819.

Fig. 3 shows an interesting document relating to the work of Robert Fulton which Mr. Suplee himself presented to the Society.

At the time Napoleon was preparing his projected invasion of England, from 1802 to 1805, Fulton, then a resident of France, offered to him a plan for the steamboat as a means of conveying his troops across the channel, during calm weather, when the British sailing vessels would be powerless. For some time the original record of this offer of Fulton's could not be found, but it is now known to be in the archives of the Conservatoire des Arts et Métiers in Paris, and, through the efforts of his friend M. Jacques Boyer, Mr. Suplee stated that he had succeeded in obtaining a photograph of it. This photograph includes a four-page letter in the handwriting of Fulton, describ-

Fig. 1 Certificate of Membership in the Insurance Society of Soho Manufactory of Boulton & Watt, Recently Discovered Among the Papers Left by Watt, and Presented to The American Society of Mechanical Engineers by Prof. John E. Sweet. One-half Size of the Original

ing fully his plans for steam navigation, together with a complete drawing of the steamboat, representing the machinery practically as it was subsequently employed on the Clermont. This letter is addressed to the Commission to whom Fulton was referred by Napoleon, consisting of MM. Molard, Bandell, and Montgolfier, but their adverse report prevented the plan from being put into execution, otherwise it is possible that the fate of Europe might have been changed. It is interesting to note that Montgolfier, the inventor of the

FIG. 2 WATT'S WORK ROOM AT HEATHFIELD HALL

balloon, was a member of the commission that rejected Fulton's plan.

These documents are dated 4 Pluviose, year XI, in the French Republican Calendar, corresponding to January 25, 1803, thus antedating by about three and a half years the first trip of the Clermont on the Hudson.

We give below a translation made by Mr. Suplee of the letter of Fulton to the French Commission:

Letter of Fulton to the French Commission

[Translation]

PARIS 4 Pluviose, Year XI (25 January, 1803).

Robert Fulton to Citizens Molar, Bandell and Montgolfier.

FRIENDS OF THE ARTS—I send you herewith sketch designs of a machine which I am about to construct with which I propose soon to make experiments upon the towing of boats upon rivers by the aid of fire engines. My original object in attempting this was to put it in practice upon the great rivers of America where there are no roads suitable for hauling nor indeed are any hardly practicable, and where, in consequence, the cost of navigation by the aid of steam would be put in comparison with the labour of men and not with that of horses as in France.

You can see that such a discovery, if successful, would be infinitely more important in America than in France where there exists everywhere roads suitable for hauling, and companies established for the transport of merchandise at such moderate charges that I doubt very much if a steam boat, however perfect it might be, could be able to gain anything over horses for merchandise. But for passengers it is possible to gain something because of the speed.

In these plans you will find nothing new, since this is not the case with paddle wheels, an appliance which has often been tried and always abandoned because it was believed that it had a disadvantageous action in the water. But, after the experiments which I have made already I am convinced that the fault is not in the wheel, but in the ignorance concerning its proportions, its speed, the power required, and probably in the mechanical combination.

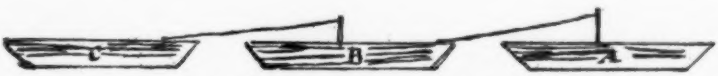
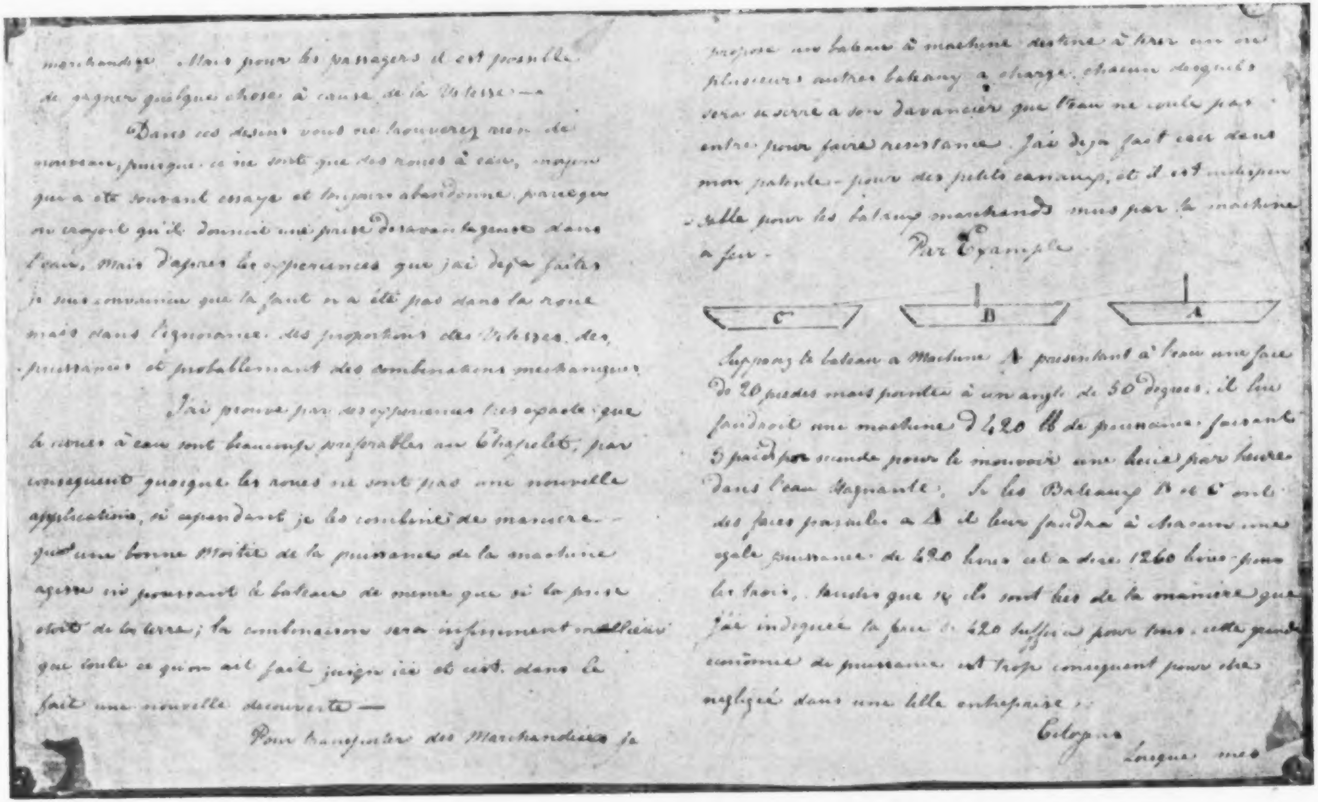


FIG. 4 SKETCH IN FULTON'S LETTER

I have proved by very accurate experiment that paddle wheels are much to be preferred to bands of paddles, and in consequence, although the wheels are not a new application, yet nevertheless I have combined them in such a manner that a large portion of the power of the engine acts to propel the boat in the same way as if they rolled upon the ground; the combination is infinitely better than anything which has as yet been done up to the present time, and it is in fact a new discovery.

For the transport of merchandise I propose to use a boat with an engine arranged to draw one or several loaded barges, each one so close to the preceding one that the water cannot flow between to make resistance. I have already done this in my patent for small channels, and this is indispensable for boats moved by fire engines.

Suppose the boat *A*, with the engine, presents to the water a face of 20 feet, but inclined at an angle of 50 degrees, it will be necessary to have a machine of 420 pounds power making 3 feet per second to move one league per hour in still water. If the boats *B* and *C* have their faces parallel to that of *A* they will each also require a force of 420 pounds, that is to say 1200 pounds for the three, while if they are connected in the manner in which I have indicated, the force of 420



marchandise. Mais pour les passagers il est possible
de gagner quelque chose à cause de la vitesse —

Dans ces desins vous ne trouverez rien de
nouveau, puisque ce ne sont que des roues à eau, moyen
qui a été souvent essayé et toujours abandonné, parceque
on croyoit qu'il donnoit une prise desavantageuse dans
l'eau. Mais d'apres les experiences que j'ai deja faites
je suis convaincu que la faute n'a été pas dans la roue
mais dans l'ignorance des proportions des vitesses, des
puissances et probablement des combinaisons mechaniques.

J'ai prouvé par ces experiences tres exacte que
les roues à eau sont beaucoup preferables au chapelet, par
consequent quoique les roues ne sont pas une nouvelle
application, si cependant je les combine de maniere
qu'une bonne moitié de la puissance de la machine
agisse en poussant le bateau de meme que si la prise
etoit de la terre; la combinaison sera infiniment meilleure
que toute ce qu'on ait fait jusqu'ici et c'est dans le
fait une nouvelle decouverte —

Pour transporter des marchandises je
propose un bateau à machine destiné à tirer un ou
plusieurs autres bateaux à charge, chacun desquels
sera serré a son davancier que l'eau ne coule pas
entre pour faire resistance. J'ai deja fait ceci dans
mon patente pour des petits canaux, et il est indispen-
-sible pour les bateaux marchands mus par la machine
a feu.

Par Exemple

C B A

Supposons le bateau a machine A presentant à l'eau une face
de 20 pieds mais pointée à un angle de 50 degrés. il lui
faudroit une machine d'420 lb de puissance, faisant
3 pieds par seconde pour le mouvoir une lieue par heure
dans l'eau stagnante. Si les bateaux B et C ont
des faces pareilles a A il leur faudra à chacun une
egale puissance de 420 livres c'est a dire 1260 livres pour
les trois, tandis que s'ils sont liés de la manière que
j'ai indiqué la force de 420 suffira pour tous. cette grande
economie de puissance est trop consequent pour être
negligé dans une telle entreprise.

Citoyens

Lorsque mes

Fig. 3 Fac-simile of the Letter of Fulton to the Commission Appointed by Napoleon in 1803. From the Original in the Conservatoire des Arts et Metiers, Paris.

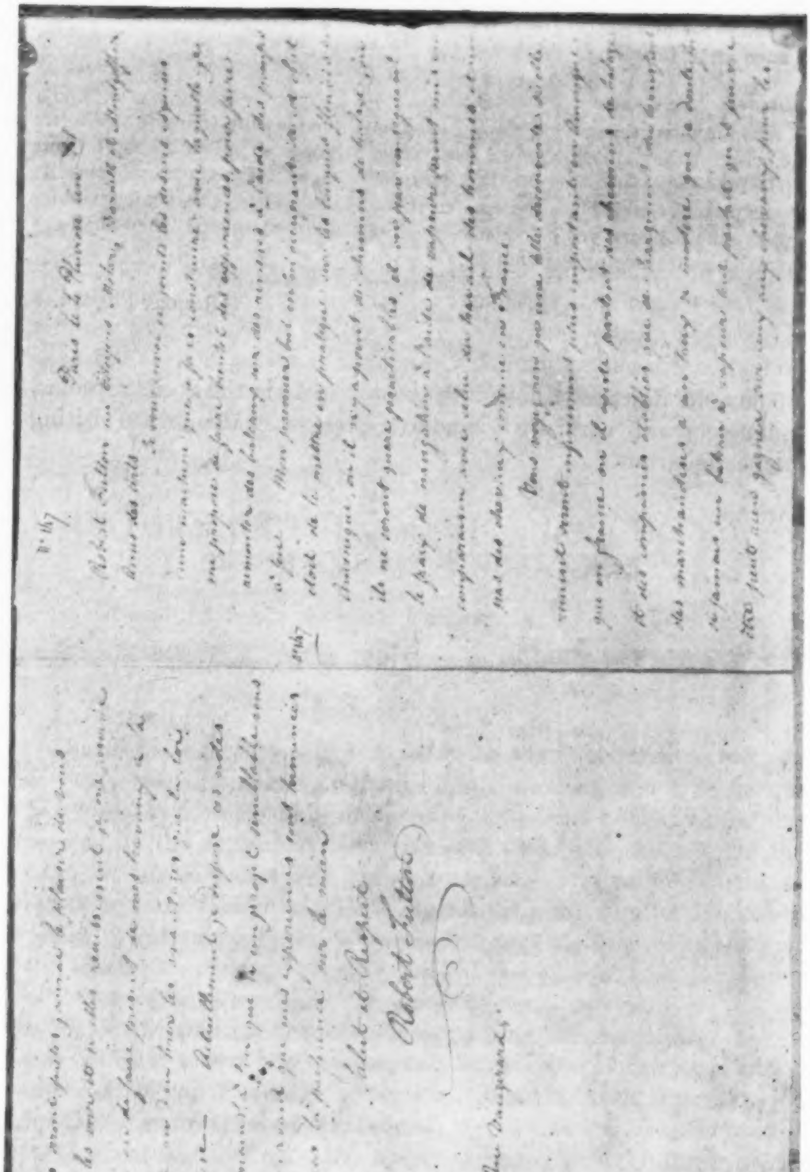

Salut et Respect
Robert Fulton

Fig. 3 Fac-simile of the Letter of Fulton to the Commission Appointed by Napoleon in 1803. For Translation, see Page 119

will suffice for all, and this great economy of power is too important to be neglected in such an undertaking.

Citizens:

When my experiments are ready I shall have the pleasure to invite you to see them, and if they are successful I reserve the privilege of presenting my labours to the republic or of taking for them such advantages as the law may authorize. At the present time I place these notes in your hands in order that if any similar project comes before you before my experiments are completed, they shall not have the preference over mine.

With respectful salutations,

ROBERT FULTON.

No. 50 *Rue Vaugirard.*

The relics described above will be on display in the Society rooms, and members are cordially invited to request to see them when visiting the headquarters.

ANNOUNCEMENT

Under the direction of the Council the Committee on Society History has arranged to present the results of its investigations to the members of the Society.

The Preliminary Report will appear in the Proceedings of the Society from month to month, and thus enable the matter to be open to comment during its completion. It is especially desired that any member who may be in the possession of facts or information bearing upon the various points as they are thus made public will communicate with the committee, in order that the final and completed report may have the advantage of the collaboration of the membership at large.

HISTORY OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Preliminary Report of the Committee on Society History

Chapter I

THE FOUNDATION

During the years immediately following the Centennial Exposition of 1876, there appeared in the United States a rapid and general development in mechanical engineering, and many of the associations created by the gatherings of engineers at that time continued in the form of acquaintance and correspondence. The establishment of the American Machinist, in 1877, furnished a medium for the publication of correspondence from engineers and mechanics, and one of the effects of such opportunities was the feeling that an organization of men devoted to mechanical engineering would be desirable.

2 In the course of correspondence, during the year 1879, between Prof. John E. Sweet, of Syracuse, and Mr. Jackson Bailey, then editor of the American Machinist, it became evident that the time was ripe for the formation of a national society devoted to the advancement of mechanical engineering. Mr. Bailey arranged with Professor Sweet that the latter should prepare a list of names to which invitations should be sent to attend a preliminary meeting to discuss the formation of a society, the intention being to hold this meeting in the office

of the American Machinist. Matters rested thus for some months, after which time Mr. Bailey learned that Professor Sweet had reconsidered the matter, and hesitated to take such an active part as the issuance of the call for the meeting on his own initiative.

3 According to the recollections of Mr. Lycurgus B. Moore, there followed a conference between Mr. Bailey and his partners, Mr. Moore and Mr. Horace B. Miller, and it was decided that Mr. Bailey should visit Syracuse at once and endeavor to persuade Professor Sweet to go ahead with the call for the preliminary meeting, Mr. Bailey being instructed to place the services of the American Machinist at his command in furtherance of the plan. The result of this visit of Mr. Bailey to Professor Sweet led to the active development of plans for a meeting.

4 Instead of acting alone, Professor Sweet communicated with Mr. Alexander L. Holley and Prof. R. H. Thurston, and it was arranged that a call for a meeting be issued by Professor Sweet. As will be seen by the following copy of the call, it was thought best not to make the matter too public, until the extent of the response should be ascertained. The letter, one of the original copies of which has fortunately been preserved, read as follows:

11 Elbridge Street, Syracuse, N. Y., January 18, 1880.

Dear Sir: It having been suggested by several prominent engineers that a national association of mechanical engineers would be desirable, and a meeting for the purpose of taking steps to organize such a society being in order, your presence is hereby requested at the office of the American Machinist, 96 Fulton Street, New York, the sixteenth day of February, 1880, at 1 o'clock sharp, at which time the necessary steps for organizing such an association will be made.

Any inquiries in regard to the meeting will be cheerfully answered.

Please avoid allowing this to be made public.

Very truly yours,
John E. Sweet.

5 These letters, sent out during the latter part of January 1880, led to a meeting on the date set, February 16, 1880, held in the editorial rooms of the American Machinist on the third floor of the building at the southeast corner of Fulton and William streets in the city of New York. The effort resulted in an attendance of thirty, with letters from eighteen others, the list being appended:

Baldwin, Stephen W.	Copeland, Chas. T.
Barnard, George A.	Coon, J. S.
Church, Wm. Lee	Couch, A. B.
Copeland, George M.	Emery, Chas. E.

Fish, John
Forney, M. N.
Grimshaw, Robert
Hemenway, F. F.
Hines, D. S.
Hoffman, Wm. H.
Holley, A. L.
Kraus, H. T. C.
Leavitt, E. D., Jr.
Lyne, Lewis F.
Newton, C. C.
Odell, W. H.
Pickering, F. R.
Porter, Chas. T.
Smith, Frank C.
Sweet, John E.
Trowbridge, W. P.
Watson, Egbert P.
Webber, Samuel S.
Webber, Samuel
Wolff, Alfred R.
Worthington, Henry R.

Letters were read from:

Cooper, John H.
Hague, Chas. A.
Hill, J. W.
Hoadley, J. C.
Kent, William,
Le Van, W. Barnet,
Lyman, E.,
Norman, Geo. H.
Parks, E. H.
Penney, Edgar
Pond, Frank H.
Richards, Chas. B.
Robbins, A. H.
See, J. W.
Swasey, Ambrose,
Warner, Worcester R.
Williams, W. J.
Woodward, F. G.

Professor Sweet called the meeting to order, and nominated Mr. Alexander L. Holley as chairman, Mr. S. S. Webber being chosen as secretary of the meeting.

6 Upon taking the chair, Mr. Holley delivered an address upon the subject of the Field of Mechanical Engineering,[1] this being an effective discussion of the character and magnitude of the work to be undertaken by the society which it was proposed to form.

7 In this address there appeared certain features which have since governed the constitution of the Society, throughout its career, and which have in a large degree favorably influenced its success.

8 Recognizing the importance of a high professional standard for membership, while at the same time appreciating the great desirability of including in the organization men whose principal effort lay in the business side of engineering, Mr. Holley suggested an arrangement which may best be given in his own words:

> Now it seems to me that all these ends can be attained in one society by simply calling professional men *members*, and fixing a high standard of qualification; and by an equal discrimination among applicants, making those *associates* who are fitted by scientific or commercial ability and relations to coöperate with engineers

[1] See Transactions, A. S. M. E., vol. 1, Opening Address of the Chairman.

The professional standard is thus maintained, while the other enumerated advantages are gained. I can see no objection to giving an associate all the privileges of the Society except the name of member.

Juniors in professional experience should, as is usual, be provided for by that classification.

9 The question of a name naturally came up almost immediately, and the suggestion of Mr. Charles W. Copeland was finally accepted and the name American Society of Mechanical Engineers was adopted.

10 A committee on organization, consisting of Messrs Henry R. Worthington, Eckley B. Coxe, Jackson Bailey, Gen. Quincy A. Gilmore, Prof. W. P. Trowbridge, M. N. Forney, and A. L. Holley was appointed.

11 A committee to nominate officers was also appointed, this committee consisting of Messrs A. L. Holley, John E. Sweet, E. D. Leavitt, Charles T. Porter and Henry R. Worthington.

12 It was decided that the meeting should adjourn to reassemble on April 7, 1880, to hear the reports of these committees, and to effect a permanent organization.

13 On the evening of the same day, February 16, 1880, the gentlemen who had thus taken the initiative in the formation of the Society gathered for a dinner at the Astor House, and among the mementoes of the occasion, preserved in the office of the American Machinist, the menu of the dinner exists, this having been presented to the Society by Mr. F. J. Miller, and treasured among its archives.

14 Thus the American Society of Mechanical Engineers was launched, and to the efforts of Professor Sweet, Professor Thurston, Mr. Holley, and Mr. Worthington, with the active coöperation of Mr. Jackson Bailey, the Society undoubtedly owes its origin, and these devoted men may well be entitled the Founders of the Society.

15 In arranging for the meeting for permanent organization, Mr. Holley conferred with Dr. Henry Morton, then President of Stevens Institute of Technology, with the result that Dr. Morton placed the large assembly hall of the Institute at Hoboken at the disposal of the Society.

16 On March 15, Mr. Holley issued a circular calling for the meeting for Wednesday April 7, 1880, at 11 o'clock a.m., at the Stevens Institute of Technology, Hoboken, New Jersey, this invitation being sent not only to those who had attended the preliminary meeting, but to a number of others who in the opinion of the committee on organization, were likely to be interested in the movement.

17 At this meeting there were eighty present, the list including the following:

Prof. S. W. Robinson	F. W. Bacon
H. R. Worthington	J. C. Bayles
Thos. R. Pickering	W. H. Scranton
Chas. B. Richards	Chas. T. Thompson
Lewis F. Lyne	Washington Jones
Samuel S. Webber	John E. Sweet
A. Vanderbilt	W. F. Durfee
John Fish	R. W. Hunt
Wm. Hewitt	Horace B. Miller
Jackson Bailey	W. L. Sweetland
F. H. Richards	H. A. Hill
Carleton W. Nason	Eben F. Wells
W. H. Hoffman	G. Leverich
F. F. Hemenway	A. H. Emery
David N. Melvin	W. H. Wiley
John L. Gill, Jr.	G. B. Mallery
John M. Wallis	E. D. Leavitt, Jr.
C. H. Brown	W. E. Ward
John Scott	Chas. T. Porter
Ed. W. Thomas	S. W. Baldwin
Wm. E. Barrows	C. C. Collins
Albert Stearns	A. B. Couch
Frederick Keppy	Jerome Wheelock
F. Firmstone	Prof. S. W. Powel
Jas. A. Burden	Horace See
F. E. Galloupe	George A. Barnard
Harris Tabor	G. C. Hawkins
J. W. Cloud	Wm. Lee Church
R. H. Soule	Geo. M. Copeland
Jos. J. White	David P. Davis
Geo. S. Strong	Robt. Grimshaw
Joshua Rose	W. B. LeVan
C. C. Newton	Chas. A. Moore
F. M. Wheeler	R. G. Ewer
L. B. Moore	W. G. Logan
M. N. Forney	H. E. Parson
Pres. Henry Morton	H. S. Hayward
W. H. Weightman	Chas. G. Buchanan
John F. Ward	Chas. Sperry
Chas. W. Isbell	Robt .Briggs
John Cotter	A. Faber Du Faur
Prof. DeVolson Wood	John Bogart

Charles P. Terry

18 Mr. Holley himself was ill, and unable to be present, and Mr. Henry R. Worthington occupied the chair, Dr. James C. Bayles, being chosen secretary of the meeting.

19 In the course of the preparations for this meeting much assistance was given to Mr. Holley by Mr. Lycurgus B. Moore, and at the meeting for organization Mr. Moore was chosen treasurer of Society.

20 Two important matters were brought out in the address made by Mr. Worthington at this meeting: the secretary was made an appointee of the council instead of being an elected officer by the membership at large. Furthermore, the question of eligibility to membership, a matter which had been rather unsettled, was arranged not to be defined by rigid standards but purposely given rather broad limitations, in order that the council and the membership committee should have sufficient liberty to decide each application on its merits.

21 At this meeting the organization of the Society was completed by the adoption of rules for its government, and by the election of the following officers and members of council:

OFFICERS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Elected April 7, 1880

PRESIDENT

Robert H. Thurston

Stevens Institute of Technology, Hoboken, N. J.

VICE-PRESIDENTS

Henry R. Worthington .... New York
Coleman Sellers .... Philadelphia, Pa.
Eckley B. Coxe .... Drifton, Pa.
Quincy A. Gillmore .... U. S. Army
Wm. H. Shock .... U. S. Navy
Alexander L. Holley .... New York

MANAGERS

Wm. P. Trowbridge .... New York
Theo. N. Ely .... Altoona, Pa.
J. C. Hoadley .... Lawrence, Mass.
Washington Jones .... Philadelphia, Pa.
Wm. B. Cogswell .... Syracuse, N. Y.
Francis A. Pratt .... Hartford, Conn.
Charles B. Richards .... Hartford, Conn.
S. B. Whiting .... Pottsville, Pa.

TREASURER

Lycurgus B. Moore .... 96 Fulton Street, New York

22 The council subsequently appointed Mr. Thomas Whiteside Rae as secretary.

MEMORIAL

COLEMAN SELLERS

Coleman Sellers, D.Sc., E.D., died at his residence, 3301 Baring Street, Philadelphia, on Saturday evening, December 28, 1907, and was interred at West Laurel Hill Cemetery on Tuesday, December 31. The funeral services were attended by a large number of personal friends and associates, including prominent representatives of the Board of Directors and of the operating organization of the Niagara Falls Power Company, many old employees of Wm. Sellers & Co., Incorporated, and others associated with him in his many activities.

MEMORIAL

Coleman Sellers the youngest son of Coleman and Sophonisba (Peale) Sellers, was born in Philadelphia, January 28, 1827. His father was a man of broad culture and influence, an ingenious mechanical engineer and a manufacturer of considerable reputation in his day. His grandfather and great-grandfather had been well known engineers, who served in turn on important commissions connected with public road and canal improvements, and each of his progenitors since the family came to Pennsylvania in 1682 had evinced marked mechanical and inventive ability and a taste for scientific pursuits.

His maternal grandfather was Charles Wilson Peale, the portrait painter, naturalist and versatile genius, distinguished for his diversified knowledge and untiring activities.

In fact if there is any foundation for the theory that heredity plays a part in shaping one's proclivities, it might be said that the preparation of his career commenced in the generations that preceded him.

He was but five years old when his father died and his instruction thereafter devolved upon his mother. This was supplemented by a system of manual kindergarten devised for him, in the belief, as his parents had been taught, that the training of the hand as well

as of the mind has an important influence upon the all around development of the individual.

Later he attended private schools in Philadelphia and finally at the age of eleven entered Bolmar's Academy at West Chester, conducted by Anthony Bolmar, a Frenchman and former officer under Napoleon, who made his school famous by his personal influence, high sense of justice and honor and his rigid discipline.

His interest in the solution of physical problems was stimulated by the elementary lectures in natural philosophy, which were given to the students by the local talent available, but the indefinite character of information derived from this source and the lack of good text books on scientific subjects aroused his natural curiosity to know more accurately the causes for certain effects. Thus we find him devoting much of his spare time to making apparatus to demonstrate practically the theories imperfectly enunciated in the classroom, and this trend of his mind is indicated by the entries in his diary, which he was then methodically keeping. Methods thus instituted by frequent repetition became habits which characterized his life work, and whenever any new discovery in the world of science or industry was announced, it came naturally to him to investigate it fully, and very often, in his thorough mastery of the subject, he improved upon the previous method or product.

He completed the course at Bolmar's Academy in his seventeenth year, and acceding to his mother's wishes, began to devote himself to practical agriculture on the farm of one of his kinsmen. Here his natural proclivity to put into service his mechanical bent whereever applicable asserted itself in attempts to improve the implements he found on the farm and among other devices he designed a metal toothed hay rake mounted on wheels, which anticipated by many years the machine later re-invented and now generally in use.

After two years of this service his brothers, who were operating the Globe Rolling Mill in Cincinnati, Ohio, responded to his desire for an opportunity to enter the mechanical field by offering him employment.

With his customary assiduity he applied himself to acquiring a knowledge of the details of the mills and processes incident to the rolling of wire rods, merchant iron and flat rails, as used at that time on the railroads of the West. The wire mill connected with the establishment was overhauled and improved under his direction and while engaged in making wire for O'Reilly, then known as the Telegraph King of the West, he procured from him a few cells of

the battery used in the telegraph outfits of the day and repeated the experiments announced in the press as having been performed by Faraday and others, making all the necessary apparatus with neatness and precision.

During his stay in Cincinnati, young Sellers, on account of his prompt and thorough investigations of discoveries as they were announced, became the mentor of a coterie of intellectual men who looked to him to elucidate the subjects under consideration and thus he was frequently called upon to entertain his friends by carefully prepared lectures illustrated by practical experiments involving chemistry, electricity and physics. He became an active member of the Mechanics' Institute and read many papers on pertinent subjects before its meetings.

He soon became Superintendent of the Globe Iron Works, and during 1850–1851 undertook the building of locomotives of their own design for the Panama Railroad. It was at this time that he married Cornelia Wells, daughter of Horace Wells of Cincinnati, one of the pioneer type founders of the West, and thus began a life long union of mutual devotion and sustained happiness.

Upon the completion of the Panama Railroad engines he was induced to enter the service of James and Jonathan Niles in charge of their locomotive works in Cincinnati, and remained there until 1856 when on the solicitation of his kinsmen, William Sellers & Co., he accepted the position of chief engineer in their works at Philadelphia.

He remained with this firm for over thirty years, being admitted to partnership in 1873. During this time he designed a great variety of machinery, covering not only all the usual machine tools, but a large number of special machines for various purposes, all of which were characterized by originality of conception, the application of correct mechanical principles and that simplicity and elegance of design which has since been followed by builders of machinery the world over. His capacity of invention is attested by the long list of patents which bear his name, either alone or associated with others, and through his initiative the modern system of transmission of power by shafting was established.

While actively engaged in the arduous duties of chief engineer of this large and growing concern, Mr. Sellers still found time for much work of scientific character often suggested by questions that arose in his business and by matters of public concern. In 1858, when the new art of photography began to supplant the ambrotypes and

daguerreotypes of the day, Mr. Sellers at once became interested in it, primarily to make its use applicable for the illustration of machinery for advertising purposes. He quickly learned the art, and not only acquired considerable skill as an amateur, but in the course of this diversion he invented valuable improvements in processes and apparatus. During 1861–1862 he acted as American correspondent for the British Journal of Photography and was for many years a frequent contributor to American photographic publications. He was one of the founders of the Philadelphia Photographic Society and a prominent member of the Amateur Exchange Club. In 1861 he made and patented a device which he called the kinematoscope, which was a forerunner of the present moving picture machine. The machine accomplished its object in a practical manner, showing pictures of objects in motion, and it only required for its full development instantaneous photography for which at that time sufficiently rapid plates were not available.

For the accomplishment of the requirements which his scientific research demanded, he fitted up a work room in his home, equipped it with complete wood and metal working machinery and laboratory apparatus for chemical and physical and microscopic investigation and a photographic dark room.

He was thus prepared for original investigation when questions arose in his professional work which demanded solution, and it became his habit to devote to study and research those hours which are usually given to rest and recreation.

Thus it once occurred to him that valuable information might be obtained by a careful microscopic study of the stony deposit or scale, which forms in steam boilers when certain waters are used, and, entering into the investigation with his usual zeal, he prepared a number of interesting specimens by mounting sections which he ground to a transparent thinness for study with polarized light. He familiarized himself in this way with the methods of mounting microscopic specimens both wet and dry, and prepared a number of excellent slides, incidentally devoting particular attention to the diatomaceous earths and fresh water algæ. He also contrived a number of handy appliances for use in connection with this work, and later, as a matter of amusement, applied the microscope to lantern work, providing himself with an oxy-hydrogen outfit, and making his own oxygen, as this gas was not then an article of commerce.

He took up the art of telegraphic signaling as a convenience in communicating between the several departments in the extensive

establishment of William Sellers & Co., and in the course of a few months he made himself an expert operator, not only signaling, but reading messages by ear, though the average time for the acquisition of this skill is about two years. It was the same with shorthand, which, becoming interested, he quickly acquired, although his opportunities for practice were only the occasional leisure moments of his busy life. Similarly he secured one of the first typewriting machines and thereafter generally used this means of writing all his papers and correspondence.

He served with Dr. Horace Howard Furness and others as a member of the commission appointed by the University of Pennsylvania, in accordance with the bequest of the late Henry Seybert, to investigate the phenomena of modern spiritualism. These researches were begun in 1884, and continued for three years, during which time Dr. Sellers' experience was of great value to his associates in devising tests and suggesting methods of investigation and observation. His strong common sense, his thorough knowledge of natural laws, predisposed him at all times to challenge those who claimed occult powers, and enabled him to detect the impostures of charlatans. While he was entirely untrammeled by prejudice and his mind was ever open to the reception of new truths, he never was inclined to credit to supernatural agencies phenomena the occurrence of which could be explained by the operation of those forces of nature which are already recognized.

After his return to Philadelphia in 1856 he identified himself with the Franklin Institute, serving on numerous important investigating committees, and contributing largely to the interest of the meetings by timely papers, discussion and lectures. He served as vice-president for several years, and was elected president for five successive terms. He served on the board of managers over a long period and was one of the publication committee that edited the Institute's Journal. He was a member of the American Society for the Prevention of Cruelty to Animals and through his influence his friend and associate, Mr. Lippincott, established a Veterinary School at the University of Pennsylvania.

He was a charter member, and a past president of this Society and the very first technical paper presented at its first meeting in 1880 was by him, entitled "The Metric System: Is it Wise to Introduce it into our Machine Shops?" The argument in this paper was based on intimate experience gained by having personally introduced metric measurements in that part of the shops of William Sellers &

Co. where locomotive injectors were manufactured. His well known antagonism to all attempts to enforce the use of the metric system by legislative enactment induced him to write freely on the subject in the technical and newspaper press, and he also prepared, in connection with the late Dr. William P. Tathan, the adverse report which was adopted by the Franklin Institute in 1876.

During the Centennial Exhibition in 1876 he served as one of the special judges for final settlement of difficult or disputed questions of award. For his well-known scientific attainments he was decorated by King Oscar of Norway and Sweden with the order of St. Olaf, and in 1899 the University of Pennsylvania conferred on him the honorary degree of Doctor of Science.

Among the Sócieties to which Dr. Sellers belonged may be mentioned The American Society of Civil Engineers, The Society of Naval Architects and Marine Engineers, The British Institution of Mechanical Engineers, The Geneva Society of Arts, The Pennsylvania Academy of Natural Science and The American Philosophical Society. His membership in the great British engineering societies was, without solicitation, tendered him in 1884 on the nomination of a number of the most eminent men of science in England.

Dr. Sellers paid his first visit to Europe in 1884, when, as member of the board of managers of the Franklin Institute, he acted as delegate from that society to the ter-centenary of the University of Edinburgh. During a stay of several months in England he visited the large works of Sir William Armstrong and Sir Joseph Whitworth under the most favorable auspices, finding open to him also the doors of any establishment he wished to see, even those that were noted as being generally closed to all the world. In many of these he found some of his own inventions, and that designs made by him as engineer for William Sellers & Co. had been copied and were in use. His trip was extended through France, Germany, Sweden and Norway, in which last mentioned countries he met with a particularly hearty welcome.

In 1886, after a serious illness, he was unable to resume his former duties and accordingly resigned his position as engineer of William Sellers & Co., being succeeded by his son, Coleman Sellers, Jr., who on the death of William Sellers became president of the company. Subsequently he was induced to enter active practice as a consulting engineer, for which work his long practical and varied experience especially equipped him.

His knowledge of the fundamental principles of physics and

mechanics was such that they might be compared to the alphabet of a language with which he could correctly spell any mechanical device he desired to construct. With this acquirement was associated his remarkable memory of what had been already attempted or accomplished in the mechanical field, enabling him to recall past inventions and to point out old ideas which from time to time were being resuscitated.

About the time he was established in his practice as consulting engineer, Dr. Henry Morton, President of Stevens Institute, induced him to lecture before the senior class of that institution. This resulted in the establishment of a Chair of Engineering Practice, with Dr. Sellers as a non-resident member of the faculty, and his lectures delivered at intervals during a number of years, were attended, not only by the senior class, but also by members of the faculty, who received from Dr. Sellers' extended experience many hints to aid them in their instruction. In 1887 he received from Stevens Institute the honorary degree of Doctor of Engineering.

In 1889 Dr. Sellers was requested by Mr. Edward D. Adams, the well-known financier of New York, to report on the practicability of developing the available water power of Niagara Falls and its transmission from Niagara Falls to Buffalo, in the interest of what afterward developed into the Niagara Falls Power Company. The proposed utilization of the power of the falls was based upon a scheme that had been suggested by Thomas Evershed, an engineer upon the Erie Canal, who had conceived the idea of placing turbine wheels in a district more than a mile above the falls, discharging into an outlet tunnel that should inconspicuously debouch at the river edge below the falls. Legislation had been obtained upon this scheme from the State of New York, though capitalists were not immediately ready to believe that the project would be commercially profitable. Dr. Sellers' report, however, so clearly indicated the practicability of the scheme that capitalists were readily found who were willing to undertake the enterprise.

He was made consulting engineer of the Cataract Construction Company, a corporation formed to execute the work, and in June of 1890 assisted in the establishment in London of the International Niagara Commission, with power to award $22 000 in prizes for plans for the generation of power by water and its transmission to a distance by the most economic method, regardless of the medium of transmission. This commission consisted of the late Lord Kelvin, then Sir William Thompson, as chairman, with Dr. Coleman Sellers,

Lieutenant-Colonel Theodore Turretini, of Geneva, Switzerland (originator and engineer of the great water power installation on the Rhone), and Prof. E. Mascart, of the College of France, as members, and with Prof. William Cawthorne Unwin, Dean of the Central Institute of the Guilds of the City of London, as secretary.

At that time great advance had been made in the transmission of power by wire rope and by compressed air, but very little had been done in the utilization of electricity for power purposes. Inquiries and examination into the best methods of developing and transmitting power then known in England, France, Switzerland, and Italy were made personally by the officers and engineers of the company, and competitive plans were received from twenty carefully selected engineers, designers, manufacturers and users of power in Great Britain, on the Continent of Europe and in America. All of these plans were submitted to the commission in London on or before January 1, 1891, and prizes were awarded for such of the plans as were considered favorably by the commission.

The engineers who were engaged to carry out the plans of the company were organized into a board of which Dr. Sellers was made chairman. The work was begun on the construction of the tunnel, and also on the entrance canal by which the water was to be brought to the turbines. In 1893, when the tunnel was nearly completed and the time for the installation of the machinery was near at hand, the object of the board of engineers had been accomplished, and it was dissolved. It then became preëminently the task of the mechanical engineer to consider and apply the devices best adapted to so control and utilize the forces as to secure the best engineering and commercial results. Dr. Sellers was accordingly made chief engineer of the Cataract Construction Company, and while its separate organization was called for, he served also as president of the Niagara Falls Power Company. It thus devolved upon him to suggest and devise the various details of the installation at a time when its principal features were essentially experimental, and it was his wise forethought and breadth of view in dealing with the new problems that guided the enterprise safely through the complex questions that surrounded it.

Radical changes in the plans were necessary when it became evident that the proper course lay in the abandonment of Mr. Evershed's scheme of a system of distributing canals leading to factory sites where independent water wheels would be installed, and to substitute in place thereof a central power station where the generation of 50 000 horse power would be concentrated for electric transmission to

consumers located on the neighboring lands or at a distance. The first three turbines were put in operation in 1895 with a sufficient demand for power in excess of their output to warrant the installation of five additional units, which were shortly followed by two more, making in all an equipment of 50 000 horse power capacity.

The mechanical features proposed by him, including his patented design of the large dynamos and their appurtenances, largely contributed to the success of the initial installation, and have certainly greatly simplified the further extension of the plant, and this work may be justly considered the crowning achievement of his life.[1]

In taking up the practice of consulting engineer, Dr. Sellers had associated with him one of his sons, Horace Wells Sellers, and subsequently admitted to the partnership, Mr. S. Howard Rippey (a member of this Society who was his principal assistant in the Niagara work), under the firm title of Sellers and Rippey.

In the death of Dr. Sellers the scientific world loses a tireless investigator, the mechanical field a prolific inventor, and the host of admirers he leaves behind feel keenly the loss of a deep, personal friendship.

THOMAS FITCH ROWLAND

Thomas Fitch Rowland was born in New Haven, Connecticut, March 15, 1831. He was the son of George Rowland and Ruth Caroline Attwater, and a lineal descendant of the Hon. Thomas Fitch, the last Colonial Governor of Connecticut.

He attended the public schools of his native city until he was 13 years old, when he entered his father's grist mill, becoming the miller's boy.

Upon the construction of what is now the New York, New Haven and Hartford Railroad, through the city of New Haven, the mill was demolished, and he entered the employ of the railroad, and was its first apprentice in the machine shop. While in this employ he fired the third passenger train that was sent over the road from New Haven to New York.

In 1850 he left the employ of the railroad company and was appointed second assistant engineer of the Connecticut, a large side-

[1] The account of Dr. Sellers' connection with the Niagara Falls project has been derived from the able biography by the late Dr. Henry Morton in Cassier's Magazine of August, 1903, the essential data of which were furnished to him by Dr. Sellers himself.

wheel steamboat plying in the service of passenger and freight transportation between the cities of Hartford and New York. Soon after joining the Connecticut, the line was sold, and all employees in the engineering department of this steamer were discharged.

He then obtained a situation with the Allaire Works of New York, an old established engine building concern, and while there designed the engines for the U. S. Revenue Steamer Harriet Lane. In the course of time a change of ownership of the establishment occurred, and he resigned and accepted a position at the Morgan Iron Works. at that time owned and operated by George W. Quintard. There Mr. Rowland was given a commission by Mr. Quintard to prepare designs, specification and estimate of the cost of producing the machinery to be installed on board the U. S. gunboat Seminole then under construction at the Pensacola Navy Yard. Mr. Quintard obtained a contract to build this machinery, and Mr. Rowland was to take charge of the work, prepare the drawings and details of construction, and superintend the execution thereof, from its commencement until final completion. While engaged upon this work he became acquainted with Capt. James L. Day, formerly of Norwich, Connecticut, who was interested in steam vessels on the Mississippi river, about the waters of New Orleans and Lake Pontchartrain, and was negotiating with Mr. Quintard for the construction of an iron side-wheel steamboat, similar to those in use about the city of New York. Mr. Quintard eventually obtained a contract for the construction of this vessel, and Mr. Rowland was engaged by him to superintend the work. Associated with him was Mr. Samuel Sneden, a prominent builder of wooden vessels of that day. The vessel was built at Greenpoint, Long Island, and Mr. Sneden formed a partnership with Mr. Rowland for the building of wooden and iron steamships, steamboats and other structural iron work.

The first contract the new firm obtained was an order from the Croton Aqueduct Department for the building of a wrought iron water pipe of large diameter, one-quarter of a mile long, to be located on the top of the High Bridge, over the Harlem river.

One of the early contracts received by this firm was that for an iron vessel, designed by the late Capt. John Ericsson. During the partnership with Mr. Sneden, the wooden hull of the side-wheel steamboat Continental, for the New Haven Steamboat Company, and the hulls for the steamboats City of Boston and City of New York, for the New York and Norwich Transportation Company, were built. Mr. Sneden severed his connection with the firm in 1860, and Mr.

Rowland afterwards conducted the business under the name of The Continental Works. Early in 1861, during the commencement of the Civil War, he obtained a contract for the construction of a number of naval gun carriages. He also constructed for the Navy Department nineteen or twenty revolving platforms or mortar bed carriages. These revolving mortar beds, with their surmounted mortars, were installed on board a complement of vessels which became known as the Porter Mortar Fleet.

In 1861 a second contract was made with the late Capt. John Ericsson and his associates, for the building of an iron clad floating battery, afterwards known as The Original Monitor. Upon the completion of The Original Monitor, he built the monitors Montauk, Kaatskill and Passaic, also the double turreted monitor Onondaga, and the light draft gunboats Cohoes and Muskoota. In 1870 he built the ferryboats Fulton and Farragut, for the Union Ferry Company, and subsequently, the boats Atlantic and Brooklyn, for the same company.

For many years Mr. Rowland was engaged in the designing and construction of gas manufacturing plants in various parts of the country, notable among them being those of the Commercial Point Station of the Boston Gas Company, and also of the Twenty-first, Forty-fourth and Ninety-ninth Street Stations of The Consolidated Gas Company of New York. In 1887 the business of Mr. Rowland was incorporated as The Continental Iron Works, of which corporation he was the President up to the time of his death. In the early days of this corporation he designed and constructed a gas holder and steel tank, located at the Fourteenth Street Station of The Consolidated Gas Company of New York, which, at that time, was the largest of its kind in this country, and was a noted achievement in gas engineering.

For many years previous to 1887, Mr. Rowland devoted much time and thought to the art of welding iron and steel plates in various forms and shapes, and it was about this time that he designed the process, and also the apparatus, used by The Continental Iron Works in the manufacture of the Fox Corrugated and Morison Suspension furnaces, which are now universally used in the internal furnace type of boiler, so well known to engineers and boilermakers.

Mr. Rowland had been in failing health for some considerable time, but continued to be active in the business until a few months ago. He was also actively interested in many charitable and philanthropic enterprises. Mr. Rowland married in 1855, Mary Eliza Bradley, of New Haven, Connecticut, who died in March, 1902.

He was a member of many years standing of various engineering societies, clubs, etc., notably,

Honorary Member—The American Society of Civil Engineers, Society of Gas Lighting, Union League Club, American Yacht Club.

Life Member—The American Society of Mechanical Engineers, Society of Naval Architects and Marine Engineers, New Haven Colony Historical Society, Fairfield County Historical Society, American Geographical Society, New England Society, N. Y. Chamber of Commerce, American Gas Light Association.

Trustee—Webb's Academy and Home for Shipbuilders, General Society of Mechanics and Tradesmen, New York Historical Society.

The funeral services were held at the Church of the Heavenly Rest, Fifth Avenue and Forty-fifth Street, on Monday, December 16, and the burial was made in the family plot in Evergreen Cemetery, New Haven, Connecticut.

OBITUARIES

STORM BULL

Storm Bull, professor of steam engineering in the University of Wisconsin, Madison, Wis., died November 17, 1907. Professor Bull was born at Bergen, Norway, October 20, 1856, and was graduated from the Federal Swiss Polytechnic Institute at Zurich in 1877 with the degree of mechanical engineer. He came to this country and in 1879 he became instructor in mechanical engineering at the University of Wisconsin. In 1884 he became assistant professor, and in 1886 was made professor. He held this position until 1890, when he was appointed professor of steam engineering.

Professor Bull was a member of the Western Society of Engineers, in which he won the Chanute medal of 1903; the Society for the Promotion of Engineering Education of which he was vice-president in 1901–1902, and the Western Railway Club. Member and vice-president jury of awards, Class 21 of group iv, Paris Exposition, 1900. Member and acting president, jury of awards, Department of Machinery Louisiana Purchase Exposition, 1904. Member American Association for the Advancement of Science, consulting engineer for Wisconsin State Capitol Commission and Board of Regents, University of Wisconsin and others. He was the author of many scientific papers and reviews of engineering text books.

EDWARD WARREN JOHNSON

Edward Warren Johnson, was born November 2, 1860, at Hinsdale, N. Y. He erected two planing mills for the Peuna Lumber Storage Company with a capacity of 150 per day and superintended the running for about three years, from 1888 to 1891. He resigned and patented a planer knife sharpener and file. From 1893, for about two years, he did mechanical work for J. Y. Wilson Manufacturing Company, Olean, New York, after which he was superintendent of lines, connections, pumps and tanks for the Standard Oil Company, constructing and running tar paraffine plant. In 1890 he was transferred to Bayonne, N. J.

Since 1902 he was engaged in the work of master mechanic, designing and constructing a great variety of mechanical works, having directly under supervision a large force of men.

Mr. Johnson met his death through an accident at Bayonne, N. J. November 12, 1907.

MATTHIAS NACE FORNEY

Mr. Matthias Nace Forney, whose death in this city on January 14, takes another from the ranks of the earliest members of the Society who were instrumental in its organization, was born in Hanover, York County, Pa., in March 1835.

He was apprenticed to Mr. Ross Winans, building locomotives in Baltimore, chiefly for the Baltimore and Ohio Railroad. He then engaged in the mercantile business up to the time of the breaking out of the Civil War. After this Mr. Forney filled a position as draftsman in the machinery department of the Illinois Central Railroad in Chicago. He became connected with the Railroad Gazette as associate editor in 1870. He had, up to that time, been in the service of the Hinckley Locomotive Works of Boston, but was then endeavoring to introduce an invention of his own, the Forney locomotive, since used on the elevated railroads of New York. After the removal of the Railroad Gazette to New York, Mr. Forney became one of its proprietors and directed its policy on the technical side for more than twelve years, until 1884, when he retired.

He was the author of the first edition of the "Car Builders' Dictionary," and the "Catechism of the Locomotive."

NEW BOOKS

POWER, HEATING AND VENTILATION. A TREATISE FOR DESIGNING AND CONSTRUCTING ENGINEERS, ARCHITECTS AND STUDENTS. By Charles L. Hubbard. Part 1. BOILER ROOM EQUIPMENT *The Technical Press, Brattleboro, Vermont. 1908.* 8vo, cloth, 216 p. Price $2.

Contents by chapter headings: Heat; Steam; Boiler House Power; Types of Boilers; Design of Tubular Boilers; Boiler Furnaces; Boiler Settings; Chimneys; Mechanical Draft.; Liquid Fuel; Boiler Accessories; Pipe and Fittings; Valves; Special Apparatus; Boiler Corrosion; Care and Management of Steam Boilers.

(Presented by Mr. Lester G. French.)

RECHERCHES EXPÉRIMENTALES SUR LA RÉSISTANCE DE L'AIR EXÉCUTÉES A LA TOUR EIFFEL. Par. G. Eiffel. *L. Maretheux. Paris. 1907.* 4to, boards, 98 p., 17 plates.

Contents by chapter headings: Méthode et Appareil Employées; Etude des Diagrammes; Résultats des Essais; Résumé et Conclusions. *Plates.* Installation du Câble; Ensemble de l'Appareil; Rssorts Dynamométriques Suspendant la Partie Mobile; Premier Appareil de Chute; Surfaces Expérimentées; Diagrammes d'Expérience; Diagrammes de Correction; Développements de Diagrammes d'Expérience.

(Presented by the author.)

BETHLEHEM STEEL COMPANY. STRUCTURAL STEEL SHAPES, SPECIAL AND STANDARD. HAND BOOK FOR ENGINEERS, ARCHITECTS AND DRAFTSMEN. Prepared by George H. Blakeley. *South Bethlehem. 1907.* 12mo, leather, 1283 p.

(Presented by the author.)

SPECIFICATIONS FOR THE NEW WATERSIDE POWER HOUSE OF NEW YORK EDISON COMPANY. *The New York Edison Company. New York. 1907.* Cloth, 8vo, 420 p.

AMERICAN SOCIETY FOR TESTING MATERIALS. *Proceedings. Vol. 7. 1907.* Tenth Annual Meeting and List of Members. Half mor., 759 p.

STATE COMMISSIONER OF EXCISE OF THE STATE OF NEW YORK FOR THE YEAR ENDING SEPTEMBER 30, 1906. *Albany. 1907.* 8vo, cloth, 733 p.

Einfluss der Armatur und der Risse im Beton auf die Tragsicherheit. By E. Probst. *Mitteilungen aus dem Koniglichen Materialprüfungsamt. Berlin. 1907.* Paper, 144 p.

Municipal Engineers of the City of New York. *Proceedings. 1906, and General Index.* Cloth, 8vo, 212 p.

Investigation of Centrifugal Pumps. Part 1. A Discussion of the Theory of the Centrifugal Pump and Tests of a Six-Inch Vertical Centrifugal Pump. By Clinton Brown Stewart. Researches in Hydraulics. By Daniel W. Mead. *Bulletin of the University of Wisconsin. Engineering Series. Vol. 3, No. 6. Madison, Wisconsin. 1907.* Paper, 8vo, 588 p. Price 50 cents.

(Presented by the author.)

How to Burn Illinois Coal Without Smoke. By L. P. Breckenridge. *University of Illinois Engineering Experiment Station. Bulletin. University of Illinois. August, 1907.* Paper, 45 p.

Tests of Reinforced Concrete Beams. By Arthur N. Talbot. *Series of 1906. Bulletin No. 14. August, 1907. Vol. 4, No. 30. University of Illinois Engineering Experiment Station. Urbana, Illinois.* Paper, 36 p.

Report of the Commissioner of Education for the Year Ending June 30, 1906. *Department of the Interior. Washington. 1907.* Cloth, 8vo, 643 p.

Load Test of Floors. Three Floor Slabs of Reinforced Concrete on the Herbst Armocrete Tubular System. By W. Herbst. *"Red Books" of the British Fire Prevention Committee. London. 1907.* No. 125, paper, 12mo, 20 p.

American Society of Civil Engineers. *Proceedings. December, 1907. Vol. 33, No. 10.*

American Society of Naval Engineers. *Journal. November, 1907. Vol. 19, No. 4.*

Engineers' Club of Philadelphia. *Proceedings. October, 1907. Vol. 24, No. 4.*

Western Society of Engineers. *Journal. December, 1907. Vol. 12, No. 6.*

BUREAU OF STANDARDS. *Bulletin. December, 1907. Department of Commerce and Labor. Vol. 4, No. 1.* Paper.

CATALOGUES A-G. *Riehlé Brothers' Testing Machine Company.*

NEW EXCHANGES

THE ENGINEERING DIGEST. (Formerly TECHNICAL LITERATURE.) *Published by Technical Literature Co. New York.* Size 7 x 10 inches. Issued monthly, $2 per year.

CENTRAL. A MAGAZINE OF TECNHICAL LITERATURE. *Published by the City and Guilds of London Institute.* Size 6½ x 10 inches. *Exhibition Road, London.* Issued monthly, 5*s*. per year.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both as to positions and as to men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 15th of the month. The list of men available is made up entirely of members of the Society and these are on file, with the names of other good men, not members of the Society, capable of filling responsible positions, information about whom will be sent upon application.

POSITIONS AVAILABLE

02 Wanted—Firm to manufacture patented gas engine on a royalty or will sell outright.

MEN AVAILABLE

28 Member of the Society will be available for temporary employment during the latter half of 1908. Can be of immediate service in executive work, calculation and design, testing and experimental work, inspection of boilers, engines, machinery, tools and supplies; mechanical engineering of power plants a specialty; speaks French and Spanish fluently.

29 Technical graduate, five years experience in all departments of large machine company, three years superintendent of small machine shop, familiar with the purchase and installation of machine tools, desires position with opportunity to acquire an interest in the business.

30 Junior, mechanical engineer, wants position on construction work or as assistant plant superintendent of manufacturing business. Seven years experience. Good executive ability and able to organize and handle large forces. Prefers going to foreign country or the West.

31 Associate member, aged 29, desires position as chief engineer or superintendent and designer, with firm taking up the manufacture of gasolene delivery wagons or trucks; four years continuous experience in this line progressing from draftsman to superintendent and designer. Technical graduate, systematic, energetic. Present salary, $2100.

32 Mechanical engineer, expert steam and gas engine engineer, with successful experience in the line of producer gas power, wishes to connect with firm engaged in this line. Can make good in development work in connection with gas engines and producers.

33 A graduate of Worcester Polytechnic Institute, 35 years old, with experience in this country, France and Germany, as draftsman, foreman, superintendent and general manager, desires responsible position as superintendent or manager. Has made a specialty of systematizing and increasing production.

34 Junior member; graduate Worcester Polytechnic, five years successful experience as erecting engineer, designer, engineering salesman and branch office manager with large concern manufacturing general line of heating and power machinery, desires position with good opportunity for advancement.

35 Member, age 32, married, technical graduate, 10 years practical experience, desires connection offering a future, preferably in manufacture of motor wagons and trucks.

36 Technical engineer, 11 years experience in practical engineering and commercial lines, competent to take full charge of small or medium sized manufacturing company as general or works manager.

37 Member, technical graduate, 16 years in charge of design of light and medium interchangeable machinery and the tools for production, also plant construction and maintenance.

38 Member wants a small financial interest and an active position in a live, growing and profitable business, where hustling counts. Manufacturing tool line preferred—South most desirable.

39 Mechanical engineer thoroughly experienced in gas engine and automobile design desires position as mechanical engineer or superintendent.

CHANGES OF ADDRESS

ADAMS, Julius Leroy (1900), 364 Palisade Ave., Yonkers, N. Y.

ANDREW, James D. (1904), Supt. of Power Stations, Boston Elevated Ry. Co., 439 Albany St., Boston, Mass., and *for mail*, Schuyler, Nelson Co., Va.

ARNOLD, Egmont Benjamin (Junior, 1907), 23 Sentinel Bldg., Milwaukee, Wis.

BACON, George W. (1898; 1899), Mech. Engr., Member of firm of Ford, Bacon & Davis, 115 Broadway, and 23 W. 67th St., New York, N. Y.

BALDWIN, C. Kemble (1905), Room 1240 Old Colony Bldg., and 5427 Jefferson Ave., Chicago, Ill.

BIGELOW, Myron J. (1904), 30 Hollywood St., Worcester, Mass.

BLOOMBERG, Jonas H. (1903), Cons. Engr., Prolongacion 5 de Mayo No. 11, Mexico City, and *for mail*, Culiacan, Sinaloa, Mexico.

BOLE, Wm. A. (1887), Cons. Mech. Engr., 722 S. Negley Ave., Pittsburg, Pa.

BRIGHT, Holstein de H. (1905; Associate, 1906), Mgr., Iron Casting and Spring Depts., 811 Harrison Bldg., and *for mail*, 1608 Summer St., Philadelphia, Pa.

BRINTON, Willard C. (Junior, 1907), Westinghouse Elec. & Mfg. Co., E. Pittsburg, and *for mail*, 512 Franklin Ave., Wilkinsburg Sta., Pittsburg, Pa.

BROCK, Walter I. (1902), Engr., Oswego, N. Y.

BUSHNELL, Leonard T. (Junior, 1906), Engr., Mill Owners Sprinkler Co., 208 Columbia St., and The Otis, Seattle, Washington.

CHAMBERS, Norman Campbell (Junior, 1905), 2-a Calle de Bruselas No. 21, Mexico City, Mexico.

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CLUETT, Sanford L. (Junior, 1903), V. P. and Secy., Walter A. Wood M. & R. M. Co., Hoosick Falls, N. Y.

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COLE, George William (Junior, 1907), Asst. to Engr. in Charge, Westinghouse Church Kerr & Co., 10 Bridge St., New York, N. Y.

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CORNELIUS, Henry Robert (1888), Sales Mgr., Wisconsin Engine Co., 1002 Bessemer Bldg., and Darlington Road, Pittsburg, Pa.

CORNELIUS, William A. (Junior, 1893), Mgr., Natl. Dept., National Tube Co., and 1121 S. Park St., McKeesport, Pa.

COX, Frank G. (Junior, 1905), Engr., Otis Elevator Co., 9 Jackson Blvd., Chicago, Ill.

COWARD, Herbert (Junior, 1905), Coward & Long, People's Bank Bldg., Wilkes Barre, and 309 Philadelphia Ave., West Pittston, Pa.

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FINLEY, A. D. (1898; Associate, 1903), 36 Orchard St., Port Chester, N. Y.

FOUCARD, Marcel L. (1903), Mech. Engr., Bolinder mek. Uerkshad, Stockholm, Sweden.

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FREEMAN, Stuart E. (1896), Supt., The Fuller Mfg. Co.; New Haven, Conn., and *for mail*, East Mauch Chunk, Pa.

GAY, Harry (Associate, 1907), Room 1231, Grand Central Sta., New York, N. Y.

GORDON, Fred W. (1880), care of Mrs. O. T. Stayer, 43 E. Walnut Lane, Germantown, Philadelphia, Pa.

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HERDMANN, Frank E. (1889) Secy. and Treas., Enid Electric & Gas Co., Enid, Oklahoma.

HILL, Ernest R. (1907), Asst. to Ch. Engr., Electrical Traction, Pa. Tunnel and Terminal R. R., 10 Bridge St., New York, N. Y., and 76 Watson Ave., E. Orange, N. J.

HUME, William H. (Associate, 1904), Supt. of Foundries, Bucyrus Co., S. Milwaukee, Wis.

HUTCHINS, Harry C. (Junior, 1905), Draftsman, American Bridge Co., 42 Broadway, New York, N. Y.

JACOBS, Ward S. (1897; 1904), 530 Farmington Ave., Hartford, Conn.

KENT, Robert Sayre (1901), Mech. Engr., Arbuckle Bros. Sugar Refinery, and *for mail*, 253 80th St., Brooklyn, N. Y.

KING, Roy S. (Junior, 1904), Asst. Genl. Mgr., Kepple Hall Co., 1111 U. B. Bldg., and *for mail*, 1911 N. Main St., Dayton, O.

KNIGHT, Geo. Laurence (Associate, 1905), Designing Engr., Edison Electric Ill. Co. of Brooklyn, 360 Pearl St., and 1032-A Sterling Pl., Brooklyn, N. Y.

KREBS, A. Sonnin (1901; Associate, 1905), Mech. Engr., 26 E. Kiowa St., and *for mail*, 1327 N. Nevada Ave., Colorado Springs, Colo.

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LOWRY, George A. (Associate, 1897), The Lowry Fabric Mfg. Co., 321 Pine St., Pawtucket, R. I.
MATTHEWS, Fred Elwood (Junior, 1904), 33 Oakland Terrace, Hartford, Conn.
McMULLIN, Frank V. (1903), Supt., Cleveland City Forge and Iron Co., and 10 905 Superior Ave., Cleveland, O.
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NEWBURY, George K. (Junior, 1904), Steam Expert, Jones & Laughlin's Steel Co., South Side Works, Pittsburg, and *for mail*, 7 Maplewood Ave., Crafton Sta., Pittsburg, Pa.
NEWELL, William (Junior, 1907), Ch. Insp. of Factory, Fidelity and Casualty Co., 97 Cedar St., and *for mail* 200 Riverside Drive, New York, N. Y.
NILES, Francis H. (Associate, 1907), Blue Island Car and Equipment Co. W. Pullman Sta., and *for mail*, 6072 Jackson Park Ave., Chicago, Ill.
NOYES, Wm. S. (1896), Mining Engr., Mills Bldg., San Francisco, Cal.
PAINE, Henry E. (Junior, 1906), H. C. Tack Co., Cleveland, O.
PALMER, Arthur C. H. (1900), Palmarosa, Hamilton, Brisbane, Q., Australia.
PATTERSON, Peter C. (Junior, 1897), Mech. Engr., National Tube Co., 554 Frick Annex, Pittsburg, and 15th St. and Library Ave., McKeesport, Pa.
RENNER, Roland B. (Junior, 1906), 40 Forest Hill Ave., E., Cleveland, O.
ROBERTS, George J. (1888), First V. P., Public Service Corporation of New Jersey, Prudential Bldg., Newark, N. J.
ROSS, Taylor W. (Junior, 1895), Asst. Supt. of Hull Constr., Newport News Shipbuilding and Dry Dock Co., and *for mail*, 111 33d St., Newport News, Va.
SAMPLE, Morris D. F. (Junior, 1905), Mgr. of Dept., National Patent Holding Co., Railway Exchange, and *for mail* 1529 Perry St., Ravenswood, Chicago, Ill.
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SHALLENBERGER, Louis R. (1895; 1902), Griffin Wheel Co., Chelsea, Mass.
SLATER, Alpheus B. (1891), Genl. Mgr., Société Anonyme du Gaz de Rio de Janeiro, and *for mail*, Caixa 226, Rio de Janeiro, Brazil, S. A.
SPRUANCE, Wm. C. Jr. (1906), Du Pont Bldg., Wilmington, Del.
STEVENSON, Louis T. (Junior, 1907), Insp., B. &. A. R. R., and *for mail*, 28 Reed St., Pittsfield, Mass.
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WHITTED, Thomas B. (1900; 1903), Allis-Chalmers Co., First National Bank Bldg., Chicago, Ill.
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WILLE, Henry Valentin (1900), Asst. to the Supt., Baldwin Loco. Works, 500 N. Broad St., and 743 Corinthian Ave., Philadelphia, Pa.

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WILSON, Lester G. (1903; Associate, 1907), Secy. and Mech. Engr., Jas. G. Wilson Mfg. Co., 3 W. 29th St., New York, N. Y.

WINTER, Oscar (1906), Steam Engr., 1563 East Boulevard, Cleveland, O.

A SIMPLE METHOD OF CLEANING GAS CONDUITS

By W. D. MOUNT, SALTVILLE, VA.
Member of the Society

Three years ago the writer had occasion to ask for proposals on a battery of gas producers, including the design of the distributing conduit and branches, though the latter were to be built under separate contract, and by parties other than the contractors for the producers.

2 As the producers were to supply gas to furnaces in continuous operation over long periods, which, for efficient working, required very uniform conditions of heating, the question of an uninterrupted flow of gas of uniform quality became of exceptional importance. We found that all of the builders of producers whom we asked to submit specifications and quotations could, in a general way, meet the conditions of uninterrupted service; that is, it would be necessary to shut the gas off a few hours once each week, and clean the accumulated soot out of the conduits.

3 Our idea of continuous service was somewhat different. It did not mean shutting down once a week, or once each month, but meant a condition of operation absolutely without interruption for an indefinite period, and we finally made this a condition of our acceptance of the contract.

4 The installation was to be in a department already in operation for several years, and where the use of gas was not originally contemplated, therefore, the distributing conduits had to be designed to meet existing conditions of space and apparatus in a department

To be presented at the Detroit Meeting (June 1908) of The American Society of Mechanical Engineers.

already much over crowded, so much so in fact that a duplicate system of conduits, one to be in use while the other was being cleaned, designs for which were submitted by one builder as the only possible solution of the condition of uninterrupted service, was entirely out of the question, to say nothing of the greatly increased cost of installation.

5 In placing the contract our decision was not based altogether on the merits of the different producers offered, but largely on the method or system of cleaning, and a design of distributing conduits which seemed to provide the greatest facilities for meeting the imposed condition of uninterrupted service.

6 After carefully canvassing the designs submitted, a contract was placed with the Morgan Construction Company, of Worcester, Mass., through their engineer, Mr. E. A. W. Jeffries, a member of the Society who, to quote from one of his letters, was "confident a method of cleaning the conduits, which, because of conditions imposed, was the most important function to be provided for adequately, could be worked out, but which required special study, and which involved some features not heretofore fully developed." I may say at this point that the congested condition of the department in which the producer plant was to be installed, as well as the location of existing apparatus, precluded the possibility of using underground conduits, and made it necessary that an overhead system be adopted, and, as already stated, the lack of room prevented the system from being in duplicate.

7 The plan of action arranged for, as outlined by Mr. Jeffries, consisted in providing facilities in the way of openings in the conduit for blowing depositions of soot through into the stack, by means of steam jets, connections to the base of the stack being arranged for from each distributing conduit.

8 The above outlined operation was not to occupy more than fifteen minutes, during which time the gas was to be shut off, but the heat in the furnace was not to be seriously impaired. The condition of uninterrupted service, it is to be noted, was not fully met, and the writer was confident at the time, and subsequent developments proved his prediction to be correct, that when the gas was shut off, even though as small amount of time as 15 minutes, it meant shutting off the product from the furnaces, or in other words, it meant an absolute shut down of the department during the operation of cleaning.

9 The producers and distributing conduits, however, were installed as designed, and the proposed method of cleaning put into effect,

with the exception that compressed air was used in place of steam. Measured by experience gained, the method was a great success, but as a means of keeping the gas conduits clean, it was a failure.

10 It did not take long, however, to determine that the idea was alright, and that our lack of success was due to the fact that the facilities provided in the design for applying the air or steam were inadequate, as well as improperly located.

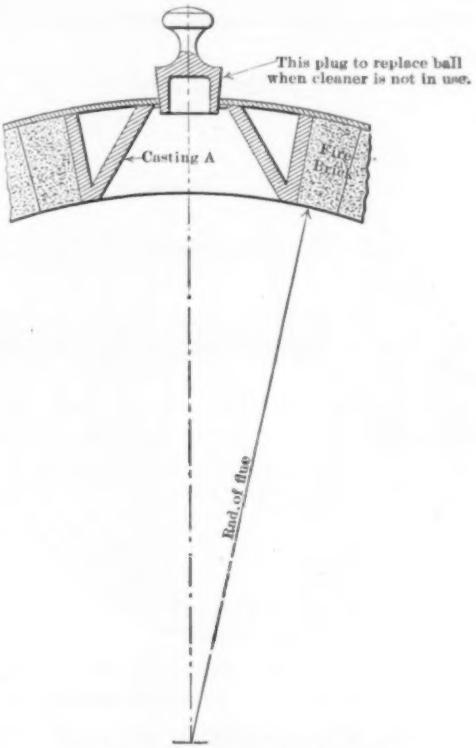

FIG. 1 CLEANING HOLE CASTING

11 The experience gained in the early days led finally to the development of the system to its present form, which is fully detailed in the accompanying sketches, Fig. 1 and Fig. 2, and which I am glad to report, has been so successful that for the past 18 months we have never for a moment had the gas shut off from our distributing conduits for the purpose of cleaning out the depositions of soot.

12 The method and apparatus, as will be noted from the drawings, are extremely simple, and quite out of proportion to the results obtained. We have so much confidence in compressed air that we are almost inclined to believe that it is one of the things essential to the successful operation of the method, another being accessibility to the main conduit and its branches. The air should be thoroughly dry and at not less than 80 pounds pressure. We find in practice that the connections from the conduit to the base of the stack are, for cleaning purposes at least, entirely unnecessary. The only time

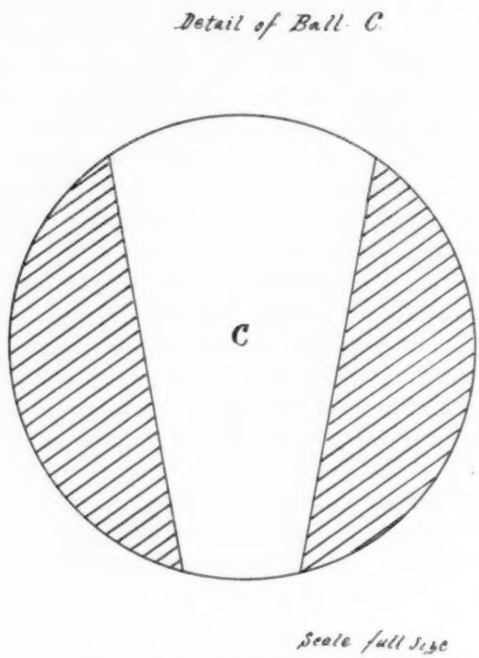

FIG. 1a BALL JOINT FOR AIR PIPE

they are used is in making repairs on the conduits when they are opened for the purpose of drafting out the gas. We also find that about 75 per cent of the soot is deposited in the drop legs immediately behind the producers, the balance being dislodged by means of the air jet from the brick lining and carried along with the current of gas to the furnaces where it is almost wholly consumed.

13 Referring to the sketches, *A A* are openings in specially designed castings (see detail *A*) spaced along the top of the conduit and of the

same depth as the brick lining. *C* is a cast iron ball of a diameter sufficient to close the opening in *A* and free to slide on the one-half inch bent pipe *B* (see detail of *C*) which is connected by hose to the air main; a one inch pipe serving also as one of the hand rails along the top of the conduit.

14 The openings *A A* are spaced at a distance nearly equal to the diameter of the conduit (although this spacing is not necessarily fixed), which we have found by experience to be about right for effective work, and in any event they should not be at a distance exceeding six feet.

15 The bent pipe *B* should be long enough to reach all parts of the conduit from *A* to *A*. The pipe, however for convenience in

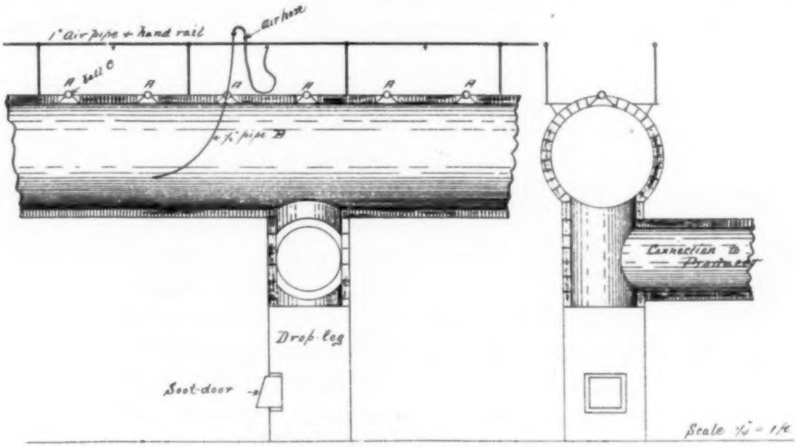

FIG 2 MAIN CONDUIT

handling cannot be over eight feet and its length, therefore, in a measure, fixes the distance from *A* to *A*. Permanently attached to the end of the pipe is a short length of air hose, having attached at the other end the male portion of a standard one-half inch Joy coupling. Located along the hand rail air pipe, at distances from two to three times the distance between *A A*, are located cocks and the female portion of the Joy coupling. Attaching the hose to the air main, therefore, is a very simple matter and consumes a minimum of time.

16 In cleaning we begin at the producers and work toward the furnaces. To the casual observer it would seem that the operator did nothing more than stick the bent pipe through the opening *A* and

turn on the air. This, however, is, of course, the most insignificant part of the operation. It is necessary that the pipe be given a circular motion, which will bring its discharge end in contact with all parts of the brick lining from one opening to another. A careful, conscientious workman will, in a little time, become very expert in the operation, and when the work is properly done it can be absolutely depended upon to remove all depositions of soot.

17 In conclusion, it is only necessary to say the gas is not shut out of the conduit during the operation of cleaning, nor is its flow in any way checked. The producers do not seem to be affected in the slightest degree; in fact cleaning is conducted absolutely without interruption to producers, conduits and furnaces, and that it is efficient is evidenced by the fact that when our conduits have been opened for repairs we have always found them clean to the brick lining.

A RATIONAL METHOD OF CHECKING CONICAL PISTONS FOR STRESS

By PROF. GEORGE H. SHEPARD, SYRACUSE UNIVERSITY
Member of the Society

The following is the notation used:

A = the area of section, by an axial plane of the piston, of the volume under steam pressure; that is, in Fig. 1, A equals twice the area $b\ c\ e\ j$.

a = the area of the section of the material of the piston by a normal cone, at the point where the stress is calculated. In Fig. 1, $e\ h$ is the trace of the normal cone.

f = the stress, along the slant height of the cone, at any point. For example, in Fig. 1, f is the tensile stress, in the line $e\ c$, at e, or the parallel compressive stress at h.

M = the moment of resistance to bending of a section of the material of the piston by a normal cone.

p = the maximum unbalanced pressure on the piston per unit of area.

R = the resultant, per unit of circumference of radius r_2 (Fig. 1) of the resistance of the cone to spreading or collapsing.

r = the outside radius of the piston (Fig. 1).

r_1 = the radius from the axis of the piston to the neutral axis of a section of the material of the piston by a normal cone, at the point where the stress is to be calculated (Fig. 1).

r_2 = the radius of the cross-section of the volume under pressure by the plane of R (Fig. 1).

r_3 = the maximum radius of the conical part of the piston.

To be presented at the Detroit Meeting (June 1908) of The American Society of Mechanical Engineers.

S = the total pressure on the piston, perpendicular to any axial plane. For example, in Fig. 1, S is the total pressure perpendicular to the plane whose trace is OX.

t = the thickness of the material of the piston at the point where the stress is to be calculated.

y = the radius of any point on the surface of the piston about the axis of the piston (Fig. 1).

θ = the angle between that axial plane of the piston, which is taken as the plane of reference, and any other axial plane (Fig. 1).

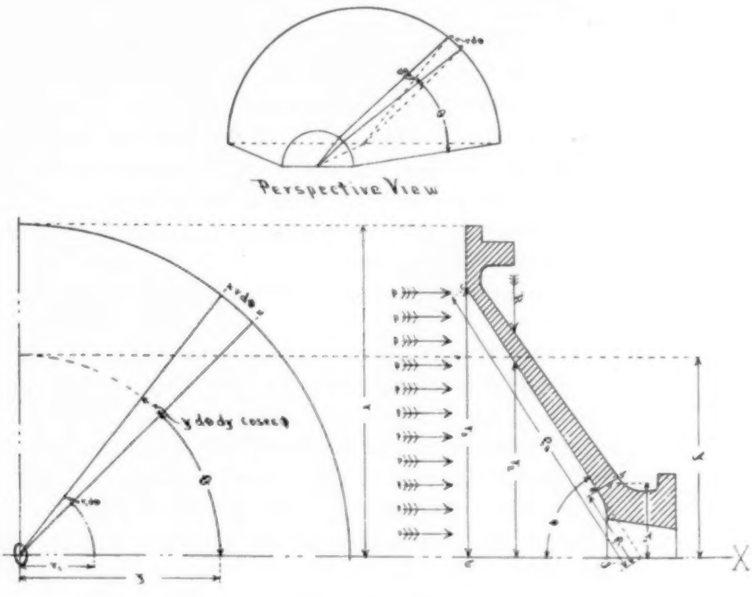

FIG. 1

ρ_1 = the slant height of the cone, on the side under the larger pressure, at the point where the stress is to be calculated (Fig. 1).

ρ_3 = the slant height of the whole cone, on the side under the larger pressure (Fig. 1).

ϕ = the angle between any slant height of the cone and the axis of the cone.

2 Differences of form prevent the deduction of a perfectly general formula, but the method explained below may be used to work out the stress in any case.

3 Considering any frustum of the cone between the base and the surface of a normal cone whose trace is *e h* (Fig. 1), it is apparent that it is acted upon by the following forces:

A The total unbalanced pressure, which is p times (area of surface of frustum, including the area of the circumferential flange).

B The resistance of the cone to spreading or collapsing.

The resultant of this acts in that plane, perpendicular to the axis of the cone, of which R in Fig. 1 is the trace, and is R per unit of circumference of radius r_2, the value of r_2 remaining to be found.

C The shearing force at slant height ρ_1, along the section by the normal cone.

D The tension and compression in the material, at slant height ρ_1 perpendicular to the section by the normal cone.

4 Consider as a free body an elemental sector, formed by two axial planes, making the angle $d\,\theta$ with each other (Fig. 1) and by the normal cone whose trace is *e h*, at slant height ρ_1.

5 First consider the piston as loaded on the inside of the cone, as as in Fig. 1.

Take moments about the neutral axis of the section *e h*.

Then for equilibrium

(Moment of pressure) =
(Moment of resistance of the cone to spreading) +
(Moment of resistance of cross-section *e h*).

6 Considering an elemental area on the surface of the cone, its area $= y\,d\,\theta\,d\,y\,cosec\,\phi$.

The pressure normal to the cone per unit of area $= p$.

Therefore the element of moment $= p\,cosec^2\,\phi\,(y - r_1)\,y\,d\,y\,d\,\theta$ and the moment of the pressure on the whole cone

$$= \int_{r_1}^{r_3}\int_0^{2\pi} p\,cosec^2\,\phi\ (y - r_1)\ y\,d\,y\,d\,\theta$$

$$= 2\pi\,p\ cosec^2\,\phi\left(\frac{r_3^3}{3} - \frac{r_1 r_3^2}{2} + \frac{r_1^3}{6}\right)$$

7 In addition to this there is the moment of the pressure on the circumferential flange

$$= p\int_{r_3}^{r}\int_0^{2} (y - r_1)\ y\,d\,y\,d\,\theta$$

$$= 2\,\pi\,p\left(\frac{r^3}{3} - \frac{r_3^3}{3} - \frac{r_1 r^2}{2} + \frac{r_1 r_3^2}{2}\right)$$

8 Therefore the whole moment of the pressure

$$= 2\pi p \left\{ cosec^2 \phi \left(\frac{r_2^3}{3} - \frac{r_1 r_2^2}{2} + \frac{r_1^3}{6} \right) + \left(\frac{r^3}{3} - \frac{r_2^3}{3} - \frac{r_1 r^2}{2} + \frac{r_1 r_2^2}{2} \right) \right\}$$

9 The resistance of the cone to spreading, for the elemental sector,

$$= R r_2 \, d\theta$$

10 The component of this, perpendicular to the reference plane, whose trace is OX (Fig. 1).

$$= R r_2 \sin\theta \, d\theta.$$

11 If the cone be bisected by the plane of OX, the component perpendicular to OX, of the resistance of either half to spreading

$$= R r_2 \int_0^{\pi} \sin\theta \, d\theta$$
$$= 2 \, R r_2.$$

12 For equilibrium this must equal the total pressure, perpendicular to the axial plane whose trace is OX, which is equal to S.

$$\text{Then } S = p A$$
$$\text{and } 2 R r_2 = p A$$
$$\text{Therefore } R = \frac{p A}{2 r_2}$$

13 Therefore the resistance of the whole cone to spreading, which equals

$$2\pi r_2 \, R = \pi \, p A$$

14 Considering any elemental area on the surface of the cone, it is apparent that, if it is in a condition of equilibrium, the unbalanced pressure upon it in a direction perpendicular to the axis of the cone, must be directly and exactly counteracted by that element of the resistance of the cone to spreading which exists over that area; for, if this were not the case, there would result an immediate deformation of the elemental surface in the direction of yielding to the greater of these two forces; but this is inconsistent with the assumed equilibrium.

15 Therefore, the resultant of the resistance to spreading acts directly opposite to the resultant of the pressure perpendicular to the axis of the cone; and, since the pressure per unit of area is uniform, its resultant acts at the center of gravity of the area exposed to pressure.

16 Since the exposed area of the elemental sector is a trapezoid, its center of gravity is at a distance from the neutral axis of $e\,h$ of

$$\frac{2}{3} \cdot \frac{\rho_3^3 - \rho_1^3}{\rho_3^2 - \rho_1^2} - \rho_1 \text{ (very approximately).}$$

Therefore the arm of R (Fig. 1) about the neutral axis of $e\,h$

$$= \left(\frac{2}{3} \cdot \frac{\rho_3^3 - \rho_1^3}{\rho_3^2 - \rho_1^2} - \rho_1\right) \cos\phi$$

17 Therefore the moment about the neutral axis of $e\,h$, of the resistance of the whole cone to spreading

$$= \pi\, p\, A \left(\frac{2}{3} \cdot \frac{\rho_3^3 - \rho_1^3}{\rho_3^2 - \rho_1^2} - \rho_1\right) \cos\phi$$

$$= \pi\, p\, A \left(\frac{2}{3} \cdot \frac{\rho_3^2 + \rho_3\rho_1 + \rho_1}{\rho_3 + \rho_1} - \rho_1\right) \cos\phi$$

18 Considering the resistance of the cross section at $e\,h$ to bending.

$$\frac{2.f}{t} = \frac{12.M}{at^2} \text{ (very approximately)}$$

and

$$M = \frac{\pi\, f\, r_1\, t^2}{3.}$$

19 Substituting in equation [1],

$$2\,\pi\, p \left\{ cosec^2\,\phi \left(\frac{r_3^3}{3} - \frac{r_1 r_3^2}{2} + \frac{r_1^3}{6}\right) + \left(\frac{r^3}{3} - \frac{r_3^3}{3} - \frac{r_1 r^2}{2} + \frac{r_1 r_3}{2}\right)\right\}$$

$$= \pi\, p\, A \left(\frac{2}{3} \cdot \frac{\rho_3^2 + \rho_3\rho_1 + \rho_1^2}{\rho_3 + \rho_1} - \rho_1\right) \cos\phi + \frac{\pi}{3}\, f\, r_1\, t^2$$

$$\therefore\ f = \left\{ 2\, cosec^2\,\phi \left(\frac{r_3^3}{3} - \frac{r_1 r_3^2}{2} + \frac{r_1^3}{6}\right) + 2\left(\frac{r^3}{3} - \frac{r_3^3}{3} - \frac{r_1 r^2}{2} + \frac{r_1 r_3^2}{2}\right)\right.$$

$$\left. - A\left(\frac{2}{3} \cdot \frac{\rho_3^2 + \rho_3\rho_1 + \rho_1^2}{\rho_3 + \rho_1} - \rho_1\right) \cos\phi \right\} \frac{3.p}{r_1 t^2} \qquad [3]$$

TABLE I CALCULATED STRESSES FOR CONICAL PISTONS

Cylinder	Maximum unbalanced pressure. Pounds per square inch	Diameter of piston. Inches	Location at which stress is calculated	Angle of Cone. Degrees.	Stress. Pounds per square inch	Material	Ultimate tensile strength of material. Pounds per square inch	Factor of safety on ultimate tensile strength	Tensile strength of material at elastic limit. Pounds per square inch	Factor of safety in elastic limit	REMARKS
H. P.	150.	22.94	Just outside hub	91	9 300	Cast iron	29 000	3.12	......	....	Thickness of piston body is uniform. Stress shown is therefore the maximum existing
I. P.	59.	34.	Just outside hub	139	38 300	Forged steel Class A, No. 1	95 000	2.48	65 000	1.7	Maximum stress
I. P.	59.	34.	Quarterway down	139	18 550		95 000	5.12	65 000	3.51	
I. P.	59.	34.	Halfway down	139	12 800		95 000	7.43	65 000	5.18	
L. P.	28.3	37.	Just outside hub	144	20 000	Cast steel	65 000	3.25	30 000	1.5	Maximum stress
L. P.	28.3	37.	Quarterway down cone	144	12 500		65 000	5.2	30 000	2.4	
L. P.	28.3	37.	Halfway down cone	144	7 270		65 000	8.95	30 000	4.13	

The above stresses were calculated for the conical pistons of the U. S. torpedo boat destroyer Truxtun.

20 Equation [3] is too complicated to permit of direct design for dimensions; but the piston may be laid out by trial, guiding one's self by empirical formulæ, and the stress at any point can then be calculated by equation [3]. It is to be remembered that, if the interior form of the piston is different from that shown in Fig. 1, the formula for stress must be deduced for the actual case by the method explained above. Ordinarily the maximum stress will occur just outside the hub.

21 It appears that the only quantity except t on the right hand side of equation [3] that is affected by changing t is r_1, and this is but slightly affected, so that f varies inversely as t^2, very nearly. If, therefore calculation shows an unsatisfactory value of f at any point, t may be varied inversely as the square root of f within wide limits, in order to bring the stress to a proper value.

22 By the above method the stress, with pressure inside, was calculated for the conical pistons of the United States torpedo boat destroyer, Truxtun, with the results shown in the following table. The odd decimals in dimension result from scaling as nearly as possible from drawings.

23 The thanks of the writer are due to Prof. C. C. Thomas of Cornell University for the use of data and for other kind assistance in the preparation of the above table.

24 Notwithstanding the differences of form, material, and unbalanced pressures, of the three pistons checked, they show factors of safety that agree fairly well at corresponding points. The minimum factor of safety shown in each case is also about what would be expected in this kind of work, in which every effort is made to reduce weight to a minimum.

25 In the above discussion the pressure has been taken as acting within the piston. When the pressure is on the outside of the piston, it may fail by buckling as well as in the ways considered above; but, in any practical case, the ratio of depth to thickness of piston will be so small that it is very probable that the piston will be stronger against buckling than against the ways of failure above discussed and therefore that only the latter need be considered. Variations in the form of the piston will affect the result and prevent the deduction of a general formula; but the application of the analysis above employed will enable a formula to be deduced for any particular case.

26 Strictly there is, in the case of inside pressure, a uniformly distributed compression; and, in the case of outside pressure, a uniformly distributed tension, over the section by the normal cone,

which should be calculated and used to modify the result by the method above discussed; but this requires no explanation. In most cases this uniformly distributed stress may probably be neglected without serious error.

DISCUSSION

THE RATIONAL UTILIZATION OF LOW GRADE FUELS

By F. E. Junge, Published in Mid-October Proceedings

Prof. Charles E. Lucke. The national importance of utilizing low grade fuels is, I think, quite fully realized. Furthermore, it has been equally well realized and proved that even these very low grade fuels can be gasified in the producer, and that the producer offers therefore a more desirable possible substitute for the boiler.

2 What has not been shown—and it is important for us as mechanical engineers to realize it as not having been shown—is the fact that such gasification of low grade fuels is not today in this country a commercial proposition. They can be gasified, but I say it is not a commercial proposition, and I can support that on three bases.

3 First, a plant to gasify these very low grade fuels will be a costly plant today, if such a plant can be built at all. An ordinary gas producer plant, handling anthracite buckwheat coal, which may be considered the standard for this sort of work, will cost more than the steam plant by a considerable margin; and first cost, gentlemen, is a matter of a great deal of importance to American power producers. If, therefore, the manufacturer can buy at all—which I doubt—a plant for the utilization of the very low grade fuels, it will cost a great deal of money.

4 Second, supposing for the moment that it could be bought, you would assuredly find the labor of operating it excessive. I have in mind a case in which a fuel that is not at all considered a low grade fuel—Pocahontas coal—costs for the firing alone, three and a half times as much in a certain producer as anthracite buckwheat did, the producer having been built for the latter. That is the second reason why I think this gasification process is not yet commercial.

5 The third reason I consider even more important than the other two, namely, the fact that in present producers there is a limit to the length of run possible, after which they must be shut down and cleaned out. That means that you must carry, if you need power continuously, a large number of spares, a number to be determined

by the length of the run possible in each and that in turn by the fue characteristics.

6 I think, however, that everybody, even remotely connected with the gas engine or gas producer enterprise, is at work on this proposition, experimenting, inventing and calculating, and I have no doubt that, with the concentration of energy the subject is now receiving, the solution of the problem is not far off.

Prof. R. H. Fernald In view of the trend of the discussion, especially that portion taken up by Professor Lucke, I want to bring out two or three points.

2 First, as to the rate of development of the gas producer for power purposes A year ago there were aproximately one hundred and fifty producer gas installations in the United States; at the present time there are over four hundred, the number having been more than doubled in the last year. Of the four hundred installations, about 15 per cent of the total number is operating on bituminous coal and 85 per cent on anthracite. The aggregate horse power represented by these installations is approximately 130 000. Of the aggregate horse power, about 70 per cent of the total is on bituminous coal, although the larger number of installations is operating on anthracite coal. The anthracite plants average about one hundred horse power each and the bituminous plants about sixteen hundred.

3 It was stated that the gas producer plant was more expensive than the steam plant. For plants of less than 1000 horse power the gas producer installation, including gas producer, engine and electric generator, costs from 15 to 30 per cent more than the corresponding steam plant. This difference can be made up by the saving in the cost of operation in approximately two years' time with coal at $2.75 a ton. With plants from 1000 horse power up to 5000, the difference in first cost is approximately from 5 to 15 per cent in favor of the steam plant, and the difference can be made up in approximately one year, with coal costing $2.75 a ton. With plants from 5000 horse power upward, the initial cost of the two types of installation is about the same.

4 A gas installation under construction at the present time—a 5500 horse power plant—has an estimated cost, including producers, engines, electric generators, buildings and auxiliaries, all erected, together with freight, of $73 a horse power. The corresponding bid for the steam plant was stated to be $74 a horse power, $1 higher for the steam than for the gas plant.

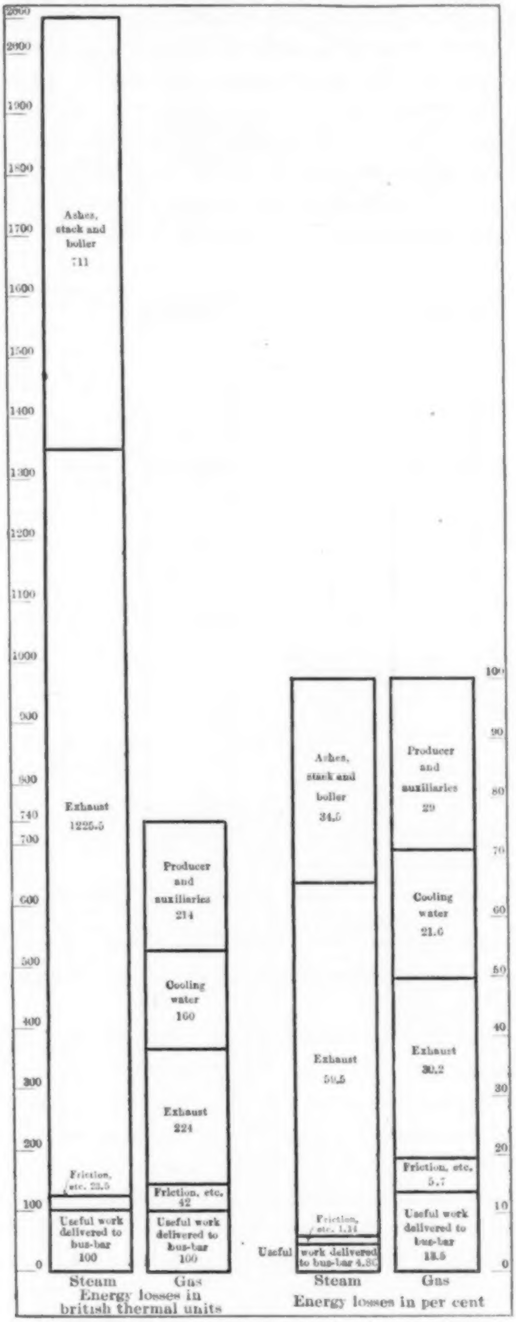

FIG. 1 RELATIVE ECONOMIES OF STEAM AND GAS POWER PLANTS

5 The next point that I desire to bring out is the relation between the amount of coal required in a steam plant and in the corresponding producer gas plant. Fig. 1 represents the relative quantities of coal required by the steam and producer gas plants at the Government Testing Station. At the left of this figure is shown the number of British thermal units that must be delivered in the fuel to the furnace and producer of the steam and gas plant, respectively in order that 100 British thermal units may be converted into electric energy. At

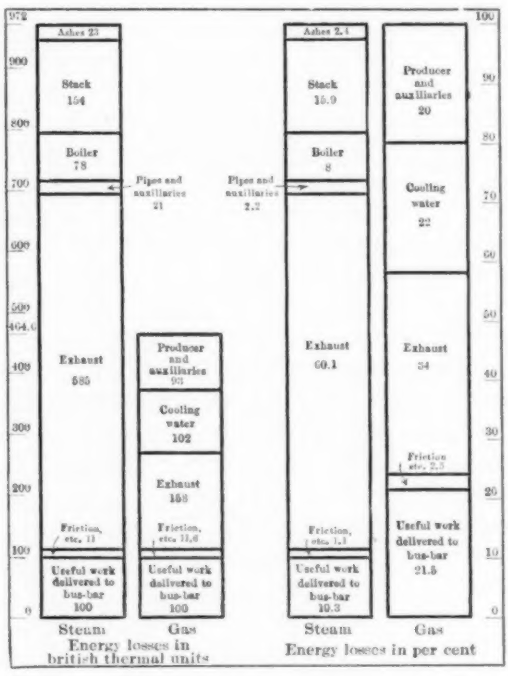

FIG. 2 RELATIVE ECONOMIES OF STEAM AND GAS POWER PLANTS

the right is shown the percentage of useful work at the bus bars for the plants considered.

6 In considering the relation between the economic results of the two types of plants under discussion, that is, steam and producer gas, attention is called to the fact that in the ordinary manufacturing plant operated by steam power, less than 5 per cent of the total energy in the fuel consumed is available for useful work at the machine. Fig. 2 shows the relation between steam and producer gas plants of exceptional efficiency. The data of the steam plant

selected for this comparison are from the figures presented by Mr. Stott, Superintendent of Motive Power, Interborough Rapid Transit Company, New York. This plant is one of the best designed and

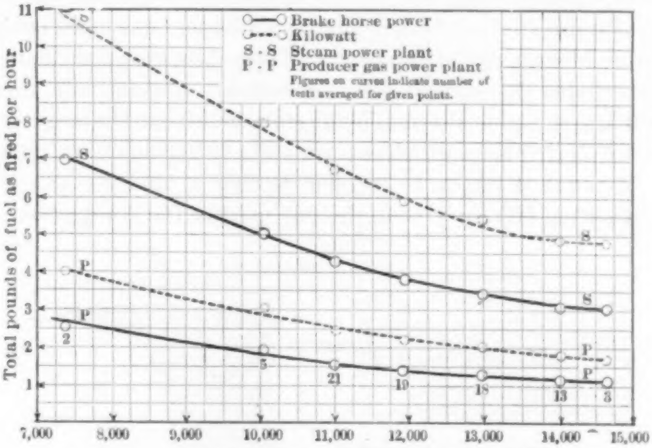

FIG. 3 COMPARATIVE POWER PLANT DUTY

B. T. U. PER POUND OF FUEL AS FIRED. 75 BITUMINOUS COALS AND 6 LIGNITES AT FULL LOAD (255 B. H. P.)

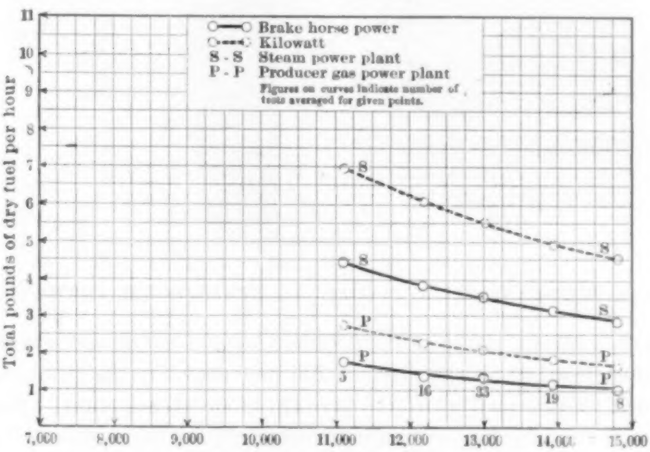

FIG. 4 COMPARATIVE POWER PLANT DUTY

B. T. U. PER POUND OF DRY FUEL. 75 BITUMINOUS COALS AND 6 LIGNITES AT FULL LOAD (255 B. H. P.)

most economically operated in this country and shows a thermal efficiency of 10.3 per cent. Various writers state the thermal efficiency of producer gas plants to be as high as 33 to 38½ per cent, and some

give figures as extravagant as "above 40 per cent. Although the intention is to present figures for a producer gas plant which may compare favorably with those of the steam plant mentioned, an effort has been made to keep well within conservative efficiencies. Attention is also directed to the fact that the producer gas plant considered should be of such size as to compare favorably with the steam plant. This precludes the suction plants which are of relatively small size but which give higher thermal plant efficiencies than the larger pressure and down-draft plants which require more or less auxiliary apparatus.

7 Although it might be possible to find a producer gas plant of higher thermal efficiency than the one used in the comparison shown

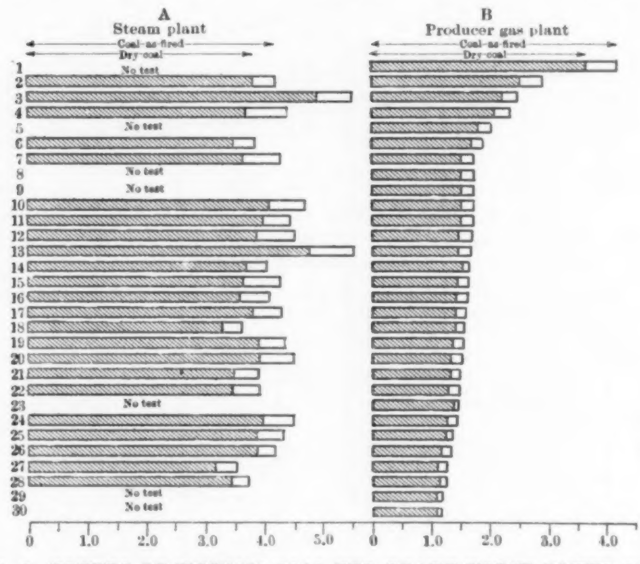

FIG. 5 POUNDS OF ILLINOIS COAL PER BRAKE HORSE POWER HOUR

in Fig. 2, a careful study of the problem has led to the use of a reasonably conservative figure, that is, 21½ per cent for the producer gas plant as compared with the 10.3 per cent of the steam plant. Another method of showing the economic results from the Government Testing Station is presented in Fig. 3 and 4. The ratio is brought out more clearly perhaps by reference to Fig. 5, which shows the results secured from a large number of different Illinois coals. In some instances no steaming test was made, as the coal was of such an inferior quality that it could not be handled under the boilers, due either to the fineness of the slack coals or to the high percentage of sulphur.

TABLE 1 RESULTS FROM HIGH ASH FUELS

	Fuel from	Size	Composition in per cent					Lbs. per hr. per sq. ft. of fuel bed		B.t.u. per pound			B.t.u. of gas	Cu. ft. of gas per lb. of			B. h. p.	Lbs. consumed in producer per b.h.p. hr.		
			Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Coal as fired	Dry coal	Coal as fired	Dry coal	Combustible		Coal as fired	Dry coal	Combustible		Coal as fired	Dry coal	Combustible
1	New Mexico	run of mine	3.62	31.56	45.19	*19.63*	0.72	6.68	6.44	11425	11853	14890	155	66.0	68.5	86.0	233.5	1.10	1.06	0.85
2	Tennessee	run of mine	3.55	26.00	49.88	*20.57*	0.76	6.89	6.64	11621	12049	15320	133	65.4	67.8	86.1	183.5	1.45	1.39	1.10
3	Iowa		16.69	31.42	31.19	*20.70*	5.50	9.43	7.87	8735	10489	13950	160	48.5	58.1	77.2	232.3	1.56	1.30	0.98
4	Wyoming		9.44	35.02	34.82	*20.72*	3.91	10.50	9.50	9650	10656	13820	151	37.0	40.9	53.0	236.8	1.70	1.54	1.19
5	Illinois	slack	12.76	32.35	33.37	*21.52*	3.82	16.90	14.70	9360	10721	14260	109	26.7	30.6	40.7	163.0	3.98	3.47	2.61
6	Wyoming	run of mine	8.63	36.81	32.83	*21.73*	4.47	10.80	9.90	9853	10784	14150	147	41.7	45.6	59.8	227.0	1.83	1.68	1.28
7	Brazil S. A.	run of mine	10.96	26.78	38.82	*23.44*	2.94	8.78	7.82	9058	10175	13810	131	48.2	54.1	73.4	167.0	2.02	1.80	1.33
8	West Virginia	bone coal	2.91	11.81	57.19	*28.08*	0.54	5.72	5.55	10545	10861	15280	106	76.8	79.2	111.4	175.2	1.26	1.22	0.87
9	West Virginia	bone coal	0.47	8.83	46.96	*43.74*	0.27	9.82	9.77	8566	8606	15350	144	44.1	44.3	79.0	228.8	1.65	1.64	0.92

8 The third point which I desire to emphasize is the fact that certain low grade fuels have been used with marked success in the producer gas investigations at the Government Testing Station. The accompanying table shows the results from nine fuels in which the percentage of ash is relatively high. In the case of No. 9, West Virginia, bone coal, the refuse was in the form of slate and rock and in many instances sparks were displayed when the rocks were struck by a hammer. Even with this exceptionally low grade fuel the consumption per horse power hour is seen to be remarkably good. Some of the lignites might be added to this list on account of their high percentage of moisture. For example, a North Dakota lignite on which very satisfactory results were secured contained approximately 40 per cent of moisture.

9 I mention these results from low grade fuels to show what work is being done in the United States along the line of their rational utilization. I recognize the fact that it may be claimed by some that the Government Testing Station is not a commercial plant. While this is, of course, true yet one opportunity only has been given the gas producer crew to secure results from each of these fuels. From our standpoint, the bone coals and the other fuels indicated can be regarded as commercially possible in the gas producer, and they can undoubtedly be operated with exceptionally good economy in the majority of cases. It should be emphasized that the producer upon which these tests were made was designed primarily for anthracite coal and that no change was made in the construction of the plant for the tests recorded in this discussion. The fuels mentioned were received at the plant at various times during the past three years and were tested in the order in which they were received, together with all the other fuels, without reference to the percentage of ash, sulphur, moisture or other properties. Over one hundred and fifty bituminous coals, lignites and peats have been thus tested in the gas producers at the Government Testing Station.

Mr. Edward J. Kunze Comparison has been made between the large size boiler, with all its refinements, and the hand fired, hand tended gas producers. It has been said that the cost of attendance is greater for the producer than for the boiler. This comparison is not fair. There is no reason, in large plants, why we should not have our producer automatically stoked and the ash automatically removed and this is indeed the only proper way of attending a large number of large producers. To be sure, we are encumbered with the extra

cost, due to the refinement, but do not superheaters, economizers, automatic stokers and ash conveyors attached to boilers also cost money?

2 If the fuel and ash are handled in as rational a manner in our large producer plants as they are in our large boiler plants, we may expect the labor cost to be very nearly in proportion to the amount of fuel burned and, therefore, for the producer, it should be at least one-half that for the boiler plant.

3 We have seen that we are to depend more and more, in the future, on the use of inferior fuels, many of which have a great tendency to form clinker. The effect of clinker formation on an ordinary grate is to reduce the effective grate area and to cause uneven heating and cooling of the grate bars with its attendant evils. The herring-bone grate is not the proper type of grate upon which to burn a clinker-forming coal. In order to prevent clinker formation, the most rational thing to do is to agitate the fuel bed slightly. The inclined grate will not do this properly. In burning a clinker-forming coal on an inclined grate stoker, the tendency is for the coal to roll down the incline, adding to its size as it rolls, much as a snow ball does in rolling down hill, leaving more or less thin or bare spaces behind it. Especially is this true where the boilers are pushed very hard, because of the greater incline given to the grate under those circumstances. A more rational sort of grate for this purpose would be a chain grate having oscillating grate bars. The occasional movements, up and down, of such a grate during its passage would not only prevent the formation of clinker of an objectionable size, but such oscillations would also keep the fuel bed and grate free of ash, and the tendency would be toward a more constant air space.

4 Common slack coal may be very successfully burned on such a grate, and the burning of culm meets with success if a proportion of bituminous coal is added. Of course the grate should be designed for the fuel to be used.

5 The fuel bed should be kept compact. This may be done by causing the ash to be pushed over a bridge wall in the rear of the grate. It is not proper to allow the caked fuel to tumble over at the end of a chain grate and break off, much as do icebergs from their mother glaciers, leaving crevices in their wake. No cool air should pass up behind the grate. All air should pass through the grate and up through hot coals, not through open places in the rear.

6 In the producer, clinker formation presents a far more serious aspect. Here we desire to generate a gas of uniform quality. When

clinker forms in a producer, the coal around its outer edges burns rapidly, leaving weak spots for the more easy passage of CO_2, air, H or other gas, hence uniformity of quality is sacrificed.

7 This trouble may be overcome in the manner indicated above, that is, by agitating the fuel bed. Poking the bed tends to pack it unduly and unevenly. Vertical stirs would cause open or at least weak places to occur in their wakes through which air, etc., may more readily pass. The proper method of stirring would therefore seem to be that in which horizontal stirrers are used, and these should have a sufficient rake in order to cause the fuel bed to be slightly lifted. Especially is this true where the down draft system is employed, on account of the greater tendency to pack.

8 The principal reason for admitting steam under the fuel bed is to break up clinker. This function is performed by the time the ash pit is reached, but it is important that at no stage preceding that of the ash pit should clinker be formed.

9 A matter requiring an even more careful consideration in the utilization of poor fuels in producers, is perhaps that of the sulphur contents in the fuel with the attendant destruction of pipe lines due to the formation of sulphurous acid when the sulphur gas given off comes in contact with water. But even this may be overcome, either by preventing contact of the gas with water and resorting to dry purification or, if the proportion of sulphur present is not too great, by adding the iron-oxid-sawdust "wash" to one or more trays in the purifier.

10 Reference has been made to the inability to get large overload capacity in the gas engine unit, and while this subject may be irrelevant to the matter under discussion, I cannot refrain from saying a few words in defense of the system.

11 I will grant that we cannot get high overloads in gas engine units. Gas engines are commonly rated at 15 per cent overload, while the steam engine and turbine give very high overloads. The restriction, in the case of the gas engine, is due to thermodynamic reasons and in the Otto or Clerk cycles, at least, we may expect little relief in the future, but need this deter us from taking advantage of its many other exceptional features?

12 The inherent thermal advantages of the gas engine can never be approached by any form of steam motor, and if the gas generating apparatus and engine receive rational treatment in their design, we may expect the required floor space to be much reduced and this may likewise be said of the cost.

13 The most rational way therefore to take advantage of the good points of each system would seem to be in designing the different units for the functions we desire them to exercise. This would call for gas engines for the uniform loads and steam turbines for the fluctuating loads, in plants having large fluctuating loads. By this dual source of power we would also be at liberty to extend our refinement. The jacket water used in the gas engines could be fed to the boilers. The exhaust gases from the gas engines could be cooled by passing through an economizer and the cooling water used for boiler feed, with the added result that we would not be troubled by any noise of exhaust.

Mr. Romyn Hitchcock The heat value of gases obtained from fuels containing much water and ash is surprising, particularly in view of the natural presumption that with low grade fuels in a producer it would be necessary to pass a considerable excess of air through the apparatus to maintain combustion. It is difficult to understand how the necessity can be avoided when a fuel contains a considerable proportion of ash. The gasification of peat containing 50 per cent or more of water with the production of 2500 cubic meters of gas of 146 thermal units is certainly remarkable. Presumably the gas carries a considerable proportion of both hydrogen and nitrogen, the presence of the latter making the gas suitable for gas engines but less desirable for heating. For while lean producer gas of suitable composition permits of most effective transformation of heat energy into power in gas engines, such gas is not relatively more desirable for steam generation than an inferior grade of solid fuel, and Mr. Junge refers to investigations which indicate that coal with 40 per cent of ash is not adapted to this purpose.

2 The heat values of gases, as shown by chemical composition, are not always proportionally available in practice. In furnaces we have to consider primarily flame temperatures and the concentration or distribution of heat. As regards combustion temperatures there is not very much difference between hydrogen and carbon monoxid, for while a pound of CO burned to CO_2 generates 4325 thermal units and a pound of H burned to H_2O 62 000, a cubic foot of each of these generates respectively only 319 and 327 units, and both require the same volume of air for combustion. A gas of low heat value may carry sufficient heat energy if it were available, to run a furnace or a steam plant, and yet be practically useless for the purpose unless pre-heated by regenerators, being in this respect like the coal referred

to containing 60 per cent of combustibles. Perhaps, therefore, the assumption that the economic solution of the problem of firing locomotives with peat or low grade fuels is to be found in the use of gas producers, is not well taken.

3 If the sensible heat of gas from a producer cannot be utilized when the gas is burned, it would seem to be desirable, for all purposes except gas engine work, to increase as much as possible the volumetric heat value of the gas. To this end the endeavor should be to utilize the hydrocarbon constituents of fuels by converting them into fixed gases. A practicable means of producing gas from low grade fuels containing hydrocarbons of sufficient heat value to permit of distribution for some distance, would be most important. Perhaps in this country there is a more promising immediate field for the application of such a process than there is for the general utilization of the distillation by-products, although it is not to be supposed that this condition will long continue. The proposal to make coke from peat and to utilize the by-products is exceedingly attractive. In this case, I understand, the by-products are of a nature to find a ready market, and the process is deserving of earnest consideration.

Professor Kent It is a great benefit to the future industries of this country that such men as Mr. Junge are making a study of gas producers and gas engines. While I believe that such a study is bound to eventuate sometime in the utilization of these low grade fuels, I also agree with Dr. Lucke that it scarcely seems to be a commercial proposition at this time.

2 Mr. Junge quotes a statement from Dr. Siemens to the effect that raw coal should not be used for any purpose whatever, but that it should be first converted either entirely into gas or into gas and coke. That statement was made by Dr. Siemens a long time ago, and a great deal of money has been lost by men who followed his ideas and attempted to run boilers with producer gas.

3 Over twenty years ago, a gentleman who had been misled by what Dr. Siemens had said, told me that he was going to change his steam boiler plant over and was going to run his boilers by gas producers, and I predicted that he would fail in the attempt, which he did. There is no better way to run a boiler than to burn coal in a furnace either underneath or immediately in front of the boiler if it is burned with the proper supply of air.

4 In regard to the possible competition of gas producer and gas engine plants with steam engine plants, I had occasion a few months

ago to witness a test of a 600 horse power Babcock & Wilcox boiler which was driven to between 1000 and 1200 horse power and fed automatically. The results were remarkable; stack temperature not very high, great overload capacity, a large steam and unusually high economy of fuel, considering the heavy load turbine occupying very little space and running at a very small cost for labor. I remarked to a friend who stood by "This postpones the day of the gas engine," and he replied, "Yes, it does."

5 There is no engineer in the world today who would attempt to duplicate a 10 000 horse-power steam turbine unit with a gas engine plant with the same first cost or with the same labor cost. It might be possible to save a little on fuel, because the gas engine is theoretically more economical than the steam engine; but taking the combinations all in all, it is very difficult to see how the advantage of steam can be overcome. At the same time there is an enormous field for the gas engine, and I expect great results from it in the future. I do not, however, like this idealizing of the subject, as Dr. Siemens did, and predicting that the gas engine and gas producer are going to wipe out the steam engine.

Mr. C. G. Atwater In connection with the use of producer gas, Mr. Junge brings out briefly a point in producer gas firing that has not, perhaps, received all the attention it deserves. Where such gas is made in large quantities and transmitted any distance, it is essential that it should be sufficiently cooled to remove the moisture. The writer recalls distinctly a large installation of producers designed to provide producer gas for furnaces of peculiar construction, in which entirely inadequate provisions were made for cooling of the gas. The consequence was that the gas arrived at the furnaces at about 80 degrees fahr. and contained so much water and tar that the heats produced were very unsatisfactory. At another plant, opportunity was given to observe closely the results of cooling producer gas. The cooling in this case was done with a coke scrubber having several trays over which cooling water was sprinkled. On warm summer days, when it was difficult to get the temperature below 80 degrees fahr., the heat fell off. On colder days, when the cooling was more efficient, say down to 60 degrees fahr., the heats were maintained with ease. As the curve of saturation with water vapor changes direction rapidly about these temperatures, a relatively small reduction in temperature eliminates considerable water, and thus adds to the efficiency of the gas.

2 In his discussion of coal tar oil, Mr. Junge refers to benzol as a product of the coal tar industry. This is correct in part; but, as a matter of fact, the main source of benzol is not the coal tar industry but the gas from by-product coke ovens which has already been deprived of its coal tar. The coal tar plants do recover a certain amount of benzol, but their output is small compared with that produced from the coke oven gas. Although the use of benzol as a fuel is on the increase in Germany, particularly in combination with alcohol, it has hardly received any attention at all in this country for such purposes; its uses here are confined almost exclusively to the enriching of coal gas and to chemical manufacture. The current English price of 90 to 50 degrees benzol in large quantities is about 9d. an English gallon or 15 cents a U. S. gallon, and these prices may be said to apply also in Germany. The calorific value of benzol of the commercial 90 degree test is about 18 000 British thermal units per U. S. gallon, or about on a par with gasolene.

3 The production of benzol in Germany is about 10 000 000 gallons per annum chiefly from by-product coke ovens, and it may be questioned if more than half of the coal coked in Germany is treated for benzol recovery. The amount of coke produced in Germany is given as 22 287 000 net tons in 1906, whereas the United States production of coke for that year was 36 401 000 net tons, more than one half as much again. Yet our recovery of benzol is so small as to be practically negligible. It is quite possible, therefore, that the development of the portable internal combustion engine may depend as much on the recovery of benzol in the future as upon the extent to which denatured alcohol is manufactured, in view of the diminishing supply of the gasolene now almost exclusively used.

4 Mr. Junge brings out in an interesting manner the advantages that the producer has for the treatment of fuels carrying a high percentage of ash. This is a point that we in the United States, where high-grade coal is so plentiful, have given but little attention. It is a fact that the ashes from the domestic fires of a large city burning mainly anthracite coal contain as high as 50 or 60 per cent of combustible matter, and it is far from being an idle dream that this waste product might readily be treated by some simple washing process and the resulting fuel brought to a better purpose than the filling in of mud flats. It is probably in this high fuel content of ordinary ashes that the promoters of the so called ash burning compounds have found sufficient success in their experiments to entrap the unwary. Indeed the high content of combustible in ashes is by no means unknown to

many industrial plants, particularly where bituminous coal is gasified in the ordinary shell producer. The writer has personally seen a very fair looking pile of ashes burning successfully on a boiler grate, under forced draft, the steam pressure being maintained during the time. The objection to such fuel is, of course, the additional labor in stoking and in handling the ashes. Gasification in a producer would probably prove a better method of recovering the combustibles in the ash. Both methods, however, are open to the suggestion that an equal amount of trouble and expense be devoted to the original methods of combustion so as to reduce the loss of fuel in the ash below a point where it would be economically possible to recover it.

5 Mr. Junge's remarks with reference to the gasification of peat containing a high percentage of moisture, are particularly interesting in this connection, and this process seems to the writer to have a more favorable outlook than any method of using peat that has been brought forward. The burden under which all these processes have hitherto labored, of having to evaporate 30 or 40 per cent of water in order to make their fuel at all combustible, is largely removed by the process he describes. The United States Fuel Testing Plant at Jamestown has made experiments with air-dried briquettes in a Taylor producer and has found that the gasification was almost ideal in its operation and results, there being practically no trouble from tar or soot. We may await with interest further information as to the results of gasified peat in a Mond producer, to which its characteristics seems to be particularly adapted.

6 Regarding the utilization of washer refuse, to which Mr. Junge also refers, the writer found it possible to utilize some thousands of tons of washer slate resulting from the washing of Dominion coal. This waste contained from 20 to 40 per cent of ash and was burned under boilers with an admixture of 50 per cent coke breeze by the use of a special furnace with forced draft. The economy was sufficient to continue this method until the available supply of slate was exhausted. The methods and results were fully described in an article to which reference is made.[1] It is possible to use coke breeze as a fuel under boilers, particularly in combination with more or less bituminous coal, provided the proper methods of combustion are resorted to. It is, however, probable that a better use can be made, as Mr. Junge suggests, by gasifying in producers or briquetting the by-product. Coke ovens at Detroit, Michigan, have for some time past

[1] Electrical World, vol. 49, p. 659, 1906.

been engaged in briquetting their coke breeze and bringing their product on the market as a high grade fuel, and the writer is informed that the process is an entire success. A paper recently read before the Michigan Gas Association by W. S. Blauvelt, states that they tried successfully briquettes of 5 to 10 pounds, then 1¼ pound later 7 ounces and 2½ ounces each. It was not until the smaller size was arrived at that they were found successful for domestic use. The breeze used was first screened through a ½ inch mesh and dried to less than 1 per cent moisture. The pitch binder was crushed to chestnut size and mixed in proper proportion with the breeze, and the whole pulverized to pass through a ⅛ inch screen. It was then heated to about 170 degrees fahr., with direct steam and was passed on a conveyor, where more steam and a little water were added to give the mixture the right consistency for easy handling. It was then pressed in a cylindrical roller press, which has a capacity of nine tons or upwards per hour. The amount of pitch binder used was 8½ to 9 per cent. The price at which these briquettes are sold at present is about \$5 per ton, this price being determined by the ability to sell the whole production. As anthracite coal sells for \$7 to \$7.50 a ton, it is, however, probable that the demand for briquettes will later admit of an increase in the price to about 50 cents a ton less than the anthracite.

Mr. W. B. Chapman The Mond by-product *process,* because of the excessive amount of steam used, is well adapted to certain coals having an ash with a low fusing point; but the Mond *producer,* as at present constructed, is not at all suited to caking coals, and many of our bituminous coals cake badly in a hand operated gas producer. Moreover, the by-product recovery business is not likely to appeal to many of our large users of power.

2 My experience leads me to believe that because a certain gas producer is said to be a complete success abroad, it will not necessarily prove so here. Many foreign producers discarded by American users bear witness to the fact that American coals and American conditions present problems which the foreign machines have apparently not yet solved.

3 In this country, for large central stations we need *large* units that will operate *uniformly* and *continuously* with a *minimum* of *labor* and a *maximum* of *efficiency,* using the *cheapest fuels.* I do not believe that all of these requirements can be attained in a hand operated gas producer, nor yet in a producer having an automatic feed,

or an automatic stirring device or an automatic ash plow. If all of the requirements mentioned are to be met, then all and not one or two of these operations should be performed mechanically and continuously.

4 The government tests at the St. Louis Exposition show that the average ton of bituminous coal tested contained 310 pounds of tar. In other words, 20 per cent of the energy in our common fuels is in a form that cannot be utilized at all for power gas in the ordinary type of producer. This would seem to suggest the down-draft type, in which the tar is converted into producer gas. The down-draft type, however, presents additional problems which are difficult to overcome in a hand operated producer.

5 In almost all lines of modern industry we find automatic machines that take in raw material at one end and deliver a continuous stream of finished product at the other, while what waste there is passes off by itself. Eventually, I believe, a gas producer will be evolved for large units that will take in fuel mechanically and deliver automatically and continuously an even flow of good gas and a constant stream of ashes.

6 A good boiler-stoker serves as an automatic feed, an automatic agitator and an automatic ash remover. If it is advisable to perform all these operations mechanically for a simple grate fire that is plainly visible and easily accessible, how much more desirable it is in a large gas producer where complicated conditions are continually arising; where the fuel bed is ten times as deep, and is neither visible nor accessible. An even, uniform fire under a boiler is desirable; but an even, uniform quality of gas for use in an internal combustion engine is imperative. A good boiler stoker will often increase the capacity of a boiler 50 per cent. Mechanically operating a gas producer increases its capacity from 100 to 200 per cent.

7 A gas of uniform thermal value is the first essential of economical combustion either in a gas furnace or a gas engine. To obtain such a gas from bituminous coal it is imperative that the producer be operated both uniformly and continuously.

8 We do not hesitate to spend large amounts in the endeavor to increase our engine efficiency a few per cent. Meanwhile we should not overlook the *greater* possibilities for economy which lie in the mechanically operated large gas producer for low grade fuels.

9 Our more expensive fuels, the kind that are now being successfully gasified, do not require much agitation or attention, especially in small sized producers; but my experience with hand operated and

mechanically operated producers, using or attempting to use the cheaper fuels, has inclined me strongly to the belief that complete mechanical operation must be developed and worked out satisfactorily in this country before we can say that the gas producer offers an entirely adequate solution for the rational utilization of our low grade fuels.

MR. L. R. POMEROY In the northwestern section of this country lignite coal is located in a district where the water is very bad indeed for boilers. As a matter of fact there are certain water tanks where if an engine should take water from them it would go "dead" in a forty-mile run. The consequence is, that locomotives on that particular division do not pull more than one-half of the rating or of the tonnage that they do on other divisions where the water is more favorable. The lignite coal in this particular section is entirely out of question for fuel under stationary or locomotive boilers.

2 The St. Louis United States Government tests, which with lignite coal of about 36 per cent moisture were able to show a consumption of little over three pounds of coal per horse power hour is very interesting in this connection from the standpoint of the possibility of generating gas power and possible electrical operation; and it occurred to the speaker that, in other districts where the water is of like character and difficult to get satisfactory results, it has put a premium on the further utilization of the power of low grade coal through gasification.

MR. W. H. BLAUVELT When the American engineer goes to Germany to study these processes for the utilization of low grade fuels he must remember that in this country the chemical manufactures are by no means in the advanced state that they are in Germany, for the working up of the by-products. We have here almost no chemical manufacturing of the more refined products of tar, such as the various colors and dyes, or the many coal tar medicines. We may almost say that our manufacture of tar products hardly goes beyond the first crude distillation of the tar, with the production of pitch and creosote oil. During the last few years a very important percentage of the total tar production of the country has been burned as fuel, on account of there being no other demand for it. I recently visited a manufacturing works which was burning daily from 20 000 to 30 000 gallons of tar under its boilers, on account of there being no market. Now we hope that these conditions will improve, and some of us are doing a good deal of hard work with that object in view, but they do exist at present.

2 Compared with the continent of Europe, the market for ammonia in this country is very small, and the great European demand for sulphate of ammonia for fertilizers is comparatively unknown here. These conditions must be kept carefully before us in our study of methods for the utilization of low grade fuels. Moreover, we must remember that tar made in the gas producer is not of the same quality as that produced by direct distillation, as in the gas works. Producer tar is the product of partial combustion, and is essentially different in composition, containing more of the paraffines, for example, and less of the valuable creosotes, anthracenes, etc. The pitch has not the same cementing qualities, and must be considered as a comparatively inferior article to good coal tar pitch. It is more like the pitch produced in the Scotch blast furnaces, for instance.

3 Dr. Lucke referred to the relative cost of gasifying coal in producers versus direct firing for boilers. I wish to second Mr. Bibbins' rejoinder that the case does not stand so strongly against the gas producer, especially if we accept as a fact Mr. Junge's presentation that gas producers can be adapted to the very low grades of fuel which could be procured for a lower cost than fuels suitable for direct firing under the boiler. I agree with Mr. Bibbins that the cost of operating producers and handling coal for them can be very greatly improved over the figures ordinarily obtained in producer plants. I believe that a large producer plant of proper design can be operated with lower labor cost than a direct fired boiler plant. I think it has been definitely shown that the superior economy in boiler firing with gas more than makes up for the loss of efficiency in the producer in the gasification of the coal.

4 In connection with the utilization of low grade fuels, I wish to call the attention of the Society to the commercial beginning of the briquetting industry in this country. The United States Government Testing Plant at St. Louis, and several private briquetting installations have made some definite steps forward in this industry. There have been some especially interesting demonstrations of the usefulness of briquetting in making valuable the great deposits of lignites in the West. I have seen these lignites briquetted at St. Louis which did admirable work in steam production, and which would stand exposure to the elements for a year without injury, while the original lignite would crumble to a fine powder within a fortnight. Briquettes are also being made commercially from the small sizes of anthracite at Scranton. The entire product, I understand, is now being sold to

railroads for locomotive use. There are other installations in Detroit, Kansas City, and on the Pacific coast, each briquetting the local fuel, and preparing them to meet the local demands. The process of briquetting is in itself a simple one, although each fuel has certain conditions which must be very accurately met and maintained, in order to produce good results. I believe we may expect to see by the development of this industry a very important utilization of many of the fuels now nearly useless.

Mr. R. K. Klein[1] Mr. Junge advocates to the American nation, rather than to the responsible and enterprising individual, to instal the fuel saving gas power plants, on the assumption that the fuel cost of a power plant is by far the largest single item of its operating expense. This is the case in Germany where a gas power plant can be built for $100 and even less per rated kilowatt; a steam plant for $70; and where a good grade of coal of 12 000 British thermal units costs $1.90 per ton at the mine and lignites of about 7500 British thermal units cost $1.25. In places distant from the mine, these prices increase rapidly on account of the high freight charges and, as a fair average, we can figure that the coal first mentioned costs $4 a ton and the other one $3. In this country, where the conditions are entirely different, it would not be economical to put in a gas power plant whose character of operation would be such as to render its installation advisable in Germany. We will find that under American conditions, not the fuel cost, but the fixed charges in the installation play the most prominent part in the operating expenses of a power plant. This is especially true in the regions of the low grade fuels. A comparison between a medium size complete gas power plant, equipped with producers for bituminous coal, and horizontal double acting gas engines and a modern steam plant equipped with steam turbines, etc., both able to carry a peak load of 3000 kilowatts, will prove this.

2 Another basis than that of a peak load in this comparison does not seem fair, as the stations must have sufficient power in them when called upon. In cases of less load we have to divide the work among the engines to the greatest advantage in each station. Prof. Charles E. Lucke points this out in his interesting paper on power cost read before the American Electrochemical Society in February, 1907.

3 For further comparison the cost at which the unit of power,

[1] Mr. R. Klein, the W. S. Barstow Company.

one kilowatt-hour can be produced shall be the basis on which will be decided what kind of plant will be the most economical. The cost per kilowatt-hour equals the operating expenses of the plant, divided by the output ranging over a whole year.

4 It should be understood that these figures necessarily cannot be universally correct, as they do not take local conditions into consideration with the exception of the price of coal and the load factor. However, they are accurate enough to be adopted as a general basis for this country.

5 The cost of a complete gas power plant, including building and foundations, coal handling apparatus, crane for power house cables, conduits and switchboards is per kilowatt of peak load $130. For a similar turbine plant this figure would be $70. Assuming the peak load 50 per cent above normal rating of station the prices per rated kilowatt would be respectively $195 and $105.

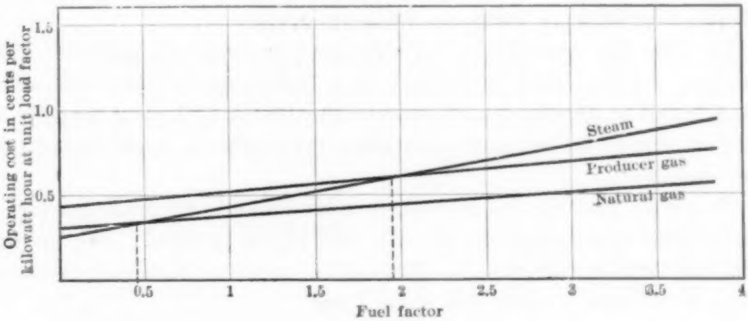

FIG. 1

6 Where natural or blast furnace gas is available, the cost of the gas power plant per kilowatt drops, respectively, to $135 and $143, on account of the omission of a producer plant. In the cost of the blast furnace gas plant, $8 per rated kilowatt is included for the gas cleaning plant. As the application of a plant running on blast furnace gas depends too much on local conditions, we only include the natural gas plant in this comparison. The appraising of the blast furnace gas varies greatly in different plants, as is pointed out clearly by Mr. H. Freyn, in his valuable paper on "Blast Furnace Gas Power Plants," presented before the Western Society of Engineers, December 1905.

7 Although on account of the greater stresses on the material of gas engines, the depreciation on the same should be assumed higher

than with the steam turbines, we rate the fixed charges for both plants alike, that is, 10 per cent on buildings and 15 per cent on machinery.

8 In the fuel consumption per kilowatt-hour we assume that a gas power plant averages 1.75 pounds and a steam plant 3.5 pounds of bituminous coal of 14 500 British thermal units.

9 The figure for the gas engine plant cannot be very much improved as the producers cannot be made of larger capacity than are used in the 2000 kilowatt station and as the higher mechanical efficiency of larger engine units is offset by lower thermal efficiency, on account of increase in ratio of cylinder volume to cylinder cooling surface, which does not permit as high a compression as with smaller engines. For steam engine plants of larger sizes the figure of 3.5 pounds of coal per kilowatt-hour can be decreased considerably, also the fixed charges when units of 5000 to 10 000 kilowatts are installed. The large stations in New York City are producing their power over 30 per cent cheaper than this estimate gives.

10 For fair comparison an allowance is made for coals of other heating values. Still there may be a difference in boiler efficiency on account of percentage of ashes in the coal, which may range from 70 per cent to 60 per cent with ashes ranging from 5 per cent to 30 per cent.

11 With poor grades of coal, provision should be made for larger grate areas than is customary with the higher grades. We do not account for this difference in efficiency, as most modern gas producers show a difference along the same lines.

12 Efficiency for producers burning cokes or anthracite is 80 per cent bituminous coal, and briquettes with tar combustion 75 per cent, bituminous coal without tar combustion 65 per cent.

13 The efficiency of a producer drop, with the load in a similar manner as that of a boiler, at three-quarter load is 96 per cent of that at full load; at one-half load it is 92 per cent and at one-quarter load it is 75 per cent.

14 In the following table it is assumed that a gas engine consumes 18 cubic feet of gas per kilowatt against a consumption of 50 cubic feet in a steam plant. The rated capacity of the plant is 2000 kilowatts, load factor 100 per cent, price of coal $1 per ton delivered on the grate, and gas ten cents per 1000 cubic feet.

15 The two most important variable items deciding the choice of the type of plant are the load factor and the price of fuel, or rather the product of the two, which we will call the fuel factor. Assuming

100 per cent load factor as unity in this product and \$1 per ton of bituminous coal of 14 500 British thermal units per pound also as unity, the fuel factor of a plant running under these conditions is unity as in the first example for coal; in the second case it is 2, in the

TABLE 1

COMPARATIVE OPERATING ECONOMY FOR GAS AND STEAM POWER STATIONS

Type of Station	GAS POWER		STEAM POWER	
Fuel	Coal	Nat. Gas	Coal	Nat. Gas
Fixed charges on buildings 10 per cent	8 000	5 000	4 600	4 600
Fixed charges on machinery 15 per cent	46 500	33 000	24 600	24 600
Office and engine room labor	6 800	6 800	6 800	6 800
Repairs	6 900	2 600	4 300	4 300
Oil and waste	5 600	5 600	3 800	3 800
Cost of fuel	15 400	32 000	30 800	89 000
Total operating cost	89 500	85 000	74 900	133 100
Cost per kilowatt-hour	0.51c.	0.485c.	0.43c.	0.76c.
If the price of the coal were \$2, and of the gas 6.8 cents the figures would be:				
Total operating cost	104 900	75 000	105 700	105 700
Cost per kilowatt-hour	0.60	0.43c.	0.605c.	0.605c.
For coal \$2, gas 20 cents they would be at one-half load factor:				
Total operating cost	same as in first example			
Cost per kilowatt hour	1.02c.	0.97c.	0.86c.	1.52c.

A little deduction in expenditures could be made for repairs and oil and waste in this last case, but would change the comparison only to a small extent.

Fig. 1 shows the cost per kilowatt-hour at unit load factor; for any other load factor the amount given should be divided by the same.

1.5 fuel factor and one-half load factor gives $5.6 : \frac{1}{2} = 1.12$ c. cost per kw-hr.

third case 1; in the first and third example it is approximately 3 for natural gas.

16. Fuels of less heating value are appraised accordingly. If coal

of 10 000 British thermal units costs 90 cents and the load factor of the station is 30 per cent and the fuel factor is:

$$\frac{14\ 500}{10\ 000} \times 0.90 \times 0.3 = 0.4$$

17 Natural gas can be appraised similarily. Gas of 6.8 cents per 1000 cubic feet of 1000 British thermal units and load factor of 100 per cent gives a fuel factor of:

$$\frac{14\ 500 \times 2000}{1000 \times 1000} \times 0.068 \times 1 = 2.0,$$ as assumed in the second example.

18 The figures show that in the natural gas regions, the gas plant wins out as long as the fuel factor is higher than 0.45, corresponding to a price of gas of 1.5 cents and unit load factor or three cents and one-half load factor or six cents and one-quarter load factor, etc.; that is in most practical cases except when the gas is idle at the well. They also show when a steam plant should be used in regions where natural gas is available.

19 We see further that plants using coal with a fuel factor of 2 and over call for application of gas engines, while with a smaller factor a steam plant is necessary to get the most economical results. On this basis an engineer may advocate the gas plant and a steam plant next door to each other, basing his advice solely upon the fuel factor. The coal being of the same price it is the load factor that decides between the two types of plants. For instance, in a case of coal at \$3 and the load factor of the station 90 per cent, or a fuel factor of 2.7, a gas engine plant would be advisable; in the same locality in a factory running full load during ten hours of the day, hence having the load factor of 1.25, a steam plant would be most economical.

20 In the regions of the low grade coals of this country where the bituminous slack coal may be bought for 40 cents a ton at the mine or for \$1 at points over 100 miles distant from it, an expensive gas plant would not be advisable, even if provisions were made for by-product recovery. Mr. Junge gives us an excellent description of this progress, but tar and its oils which he seems to consider by far the most important of these by-products are hardly marketable in this country; in fact most of the gas plants burn their tar under boilers because they cannot sell it to advantage.

21 In these regions the fuel factor cannot be larger than 2 unless the coal costs at least \$2 per ton, which is seldom the case, and then the fuel factor would be 2 only for plants running full load day and night. In view of these figures it would be decidedly a mistake to install gas power plants with by-product recovery in any of the

regions of the low grade coals and the charge of Mr. Junge to the American people of lack in technical training and industrial forethought should at least be minimized.

22 It will not do in this country to start a briquetting business with an output of 4.2 tons a day to receive $3 per ton for briquettes instead of 55 cents per ton for coal dust. The cost and difficulty of manufacturing briquettes puts them behind in competition with coal; this is also the case with the large deposits of peat which are found in this country.

23 Mr. Junge concludes by saying that the rational utilization of coals requires the adoption of gas producers and gas driven central stations. This may all be true, but we have not only to consider the utilization of coals but also that of capital and labor. Capital in the cost of the plant, labor in the manufacture of the machinery. The recent panic shows clearly that capital invested too lavishly in new enterprises is more detrimental to a country than the consumption of somewhat greater quantities of fuel where this is abundant.

24 The natural resources of this country are so abundant that even while America consumes 9000 pounds of coal and 700 pounds of iron per capita per year against 7000 pounds of coal and 320 pounds of iron for Germany, the corresponding saving in capital invested and labor cost is such as to place the American to a greater financial advantage over his German competitor. On the other hand, the American should not forget that he pays yearly a fairly high interest on the mortgage on his business in the shape of a dividend to the European shareholders of American stocks.

DUTY TEST ON GAS POWER PLANT

By J. R. Bibbins, Published in Mid-November Proceedings

Mr. W. H. Blauvelt Mr Bibbins made reference to the fact that a variation in the calorific value of the gas makes but a relatively small variation in the power developed by the gas when exploded in the cylinder, owing to the large dilution by the air necessary for combustion. The Society may be interested in some experiments made at the Massachusetts Institute of Technology to determine the percentages of air required for admixture with different gases to produce the best explosive mixtures. These experiments show that in the case of water-gas the best efficiency results when using that quantity of air which gives a theoretical maximum pressure of about 125

pounds per square inch. Using this quantity of air for the different gases (except blast furnace gas), we have the following table which shows the volumes of air per one volume of gas, and the percentage of hydrogen in the mixture of air and gas as exploded:

	Anthracite producer gas	Mond producer gas	Coke oven gas	Blast furnace gas	Natural gas
Volume of air per one volume of gas.......	1.09	1.50	8.93	0.65	12.40
Per cent of hydrogen..	7.77	8.16	4.60	0.00	1.50

2 From these last figures it is plain that the claim made by some that coke oven gas is more liable to back firing, or preignition, on account of its high percentage of hydrogen, can hardly be maintained, since the percentage of hydrogen is lower in the mixture as exploded than either anthracite or Mond producer gas.

Prof. Wm. Kent Mr. Bibbins states that this test was a service test, and not primarily for efficiency.

2 I should like Mr. Bibbins to explain in what way the performance could have been bettered. He did say something about the temperature of the jacket water and that if it had been hotter the efficiency would have been higher. I should like to have him elaborate this point and also to say what other changes would have tended to increase the efficiency. You couldn't change the size of the engine; nor the speed; nor the composition of the gas. It seems to me there was very little that could have been changed, The record of the test is very valuable and I am glad to have it, but there is one little thing to which I would like to take exception.

3 In par. 4 the author says that the engine used perhaps one-third of the coal that would have been required for steam power. Now I notice that the gas engine used 0.805 pounds coal per one horse power hour. Three times that consumption would have been 2.415 which would be the rate for a very uneconomical steam engine, and more than double the figure for the best practice. The gas men compare the gas engine with the old style steam engines. Why do they not compare it with performances of triple expansion pumping engines, which have reached a consumption of 1.05 pounds on Clearfield or Pocahontas coal, and in which there is a possibility of getting down to ninth-tenths of a pound? That is a figure which can be

reached by a steam engine; why use the steam figures from an old worn out plant 20 years old?

PROF. C. E. LUCKE The average member who has not tried to make a producer gas power plant test does not realize the difficulty of the job, and I hope that the discussion of Mr. Bibbins' paper will not degenerate into little quibbles in regard to the details of this test.

2 I think, on the whole, we are to be congratulated on getting results that are so clear and definite. There is a question I would like to have answered, concerning the peculiar behavior of the anthracite and bituminous coal in the producer, both being present at the same time. As I understand it, the bituminous coal, in gasifying during the distillation stage, carries down carbon in the volatile form to the anthracite bed and there deposits some of it.

3 If this is the case, there is a very important principle involved because certain forms of carbon gasify in producers more rapidly than others. For instance, a porous variety such as we have in charcoal, gasifies at low temperatures and rapidly, whereas carbon, in the lamp black or soot form, requires high temperature and a longer time of contact between the air or CO_2 and the carbon to effect gasification. If it is true that some of the bituminous carbon is deposited in the form of soot, on the anthracite, it would appear that because higher temperature is required to gasify it and the deposit was made at a point where the temperature was quite low, it might never be regasified. I ask Mr. Bibbins if he can throw some light on this phenomenon of transfer and redeposit of carbon.

MR. SIDNEY A. REEVE In Fig. 8 is shown a curve of producer efficiency, rising with an increase of load. I would inquire how this curve is obtained, since no observations of fuel consumption could be associated with the holder drop tests.

2 Secondly, if this curve be true, does it not show that the producer capacity was too great for the engine rating? At the maximum load recorded, an overload of 20 per cent, the producer efficiency is still rising rapidly. We naturally expect of gas producers the same general form of characteristic shown by all other devices (except the Otto type of gas engine), viz: a region of maximum efficiency at or slightly below rated load, with decreasing efficiency under overload. Undoubtedly this producer would develop such a characteristic were it pushed sufficiently. But from the diagram it does not appear to have approached its point of maximum efficiency, even at 600 horse power.

3 In par. 29 I notice discussion of the possible effect upon the hydrogen content of the gas of varying the period of water gas making. As this period is stated as amounting to only 20 or 30 seconds—occurring how often is not stated—it must be a matter of considerable moment in the efficiency of operation to end this period correctly.

4 Mr. Bibbins in describing the holder drop tests, speaks of the avoidance of variation in holder dimension by sun heat, by making the tests at night. Is not the effect of temperature upon the accuracy of such readings much more noticeable in the temperature of the gas than in the temperature of the shell? I would inquire what measures were taken to determine the temperatures of the gas at different points in the holder, and at different times.

5 I am interested in the form of characteristic of engine efficiency shown in Fig. 2, as corroborating, by the latest accepted practice, the statements made in my own paper of the present session, viz: that it is a fundamental characteristic of the best existing gas engines that the efficiency should become a maximum only at maximum overload. Mr. Bibbins' engine shows a maximum efficiency of over 26 per cent, but only at 14 per cent overload; the maximum, apparently, of which the engine is capable. If it be assumed that in usual practice an engine load will vary between 60 and 100 per cent of rating, or between 50 and 110 per cent, then the average efficiency of this engine would be less than 23 per cent, or an eighth less than the best of which it is actually capable. The misfortune of this fact, however, does not lie so much in the loss of coal involved as it does in the inadaptability of the gas engine to meet heavy overloads with a wide margin of power.

Prof. P. P. Breckenridge I should like to submit the following figures representing some recent steam turbine performance. The turbines are installed in a large Chicago power plant.

a Turbine installed four years ago, 4000 kilowatt capacity, gave a steam consumption of 23 pounds per kilowatt-hour.

b Turbine installed two years ago, 6000 kilowatt capacity, gave a steam consumption of 17 pounds per kilowatt-hour.

c Turbine installed one year ago, 9000 kilowatt capacity, gave a steam consumption of 12.93 pounds per kilowatt-hour.

CONTROL OF INTERNAL COMBUSTION IN GAS ENGINES

By Prof. C. E. Lucke, Published in Mid-November Proceedings.

Mr. Lewis H. Nash In regard to the existence of explosive waves in the cylinder of a gas engine, I am inclined to doubt whether they exist at all, and, in order to make myself clear, I will refer to a little past history.

2 In the early days I was much troubled with explosive waves. These were of such violence as to break instantly the indicator. In order to try and avoid these high vibratory motions, we drilled small holes into the cylinder and attached the indicator through the usual thread and cock furnished with the instrument. Notwithstanding our use of very stiff springs, the vibrations were frequently strong enough to break the indicator mechanism. In order to overcome this, I made a little dash pot attachment for the indicator, in which oil was placed in a cylinder containing a piston loosely fitting in the same, and by means of this dash pot I reduced the amplitude of these vibrations, until we no longer had any trouble from breaking instruments.

3 The card taken with violent explosive waves, so called, and one in which they did not appear, gave practically the same mean effective pressure. Therefore, the explosive waves did not seem to indicate any increase of power, but only the effect of an explosion.

4 One day we put the indicator close down in the head, drilled out a large hole in the cylinder and used an indicator without the dash pot. Greatly to our surprise there was no resulting disaster to the instrument. This led me to study the cause of the explosive wave action.

5 I believe, therefore, that the explosive wave action is simply a local phenomenon of the passage leading to the indicator, and that it has no existence in the body of the cylinder itself. I account for the action referred to in the following manner:

6 Suppose we have a small extended tube leading from the cylinder of an engine. This tube, after the first impulse, will contain a mixture of burnt gases. When the charge is compressed in the cylinder, a portion of this compressed explosive mixture is driven back into the tube. When the main charge is ignited the flame does not communicate itself instantly to this long, slender passage; therefore, the increased pressure in the cylinder serves to compress the gases in the tube to a pressure equal to that of the exploded charge in the main cylinder. In doing this, the small portion of unexploded mixture in this tube is ignited by compression, and in this manner

every particle of mixture in this small tube explodes at once, the effect being like that produced by dynamite or other high explosive, only on a lesser degree. This secondary explosion in the connecting tube is the one of which the indicator takes note.

7 It will, therefore, be seen that these effects can be produced, either in a chamber connected by a small passage to the engine cylinder, or in a long pipe in which the time of transmission of the flame would be longer than the ignition due to compression.

8 The remedy for this is to drill the indicator hole of the full size of the tap drill directly into the cylinder, and to place the indicator as close to the cylinder chamber as is possible. Since we have done this, I have never seen a card showing the so-called "Explosive Waves" taken from our engines.

9 I offer this as an explanation, and wish to say in closing that while it may be possible that other pockets in a combustion chamber could cause explosive waves, I believe that they would be of small amplitude in the body of the combustion chamber itself, and that those that have been shown by the indicator have their origin in the connecting passage and are simply a local phenomenon.

Prof. W. H. Kenerson In my experience these same explosions occur under all sorts of conditions; under conditions where there is no possible preignition. Where kerosene is not used, these same explosions will occur, both with and without diaphragms.

Mr. H. H. Suplee This discussion upon the division of the operation of the gas engine as regards the compression and the combustion leads me to call attention to the progress which has been made in the development of the Diesel motor in the United States. The principal difficulty with the Diesel motor, employing high air pressures, has been with the air compression pump. The air is partially compressed by a pump, directly connected to the engine, and the air delivered to the cylinder, where the final compression is effected. The American builders of the Diesel engine have modified this in a very practical manner by using an independent, two-stage compressor of a standard commercial type, driven by the motor, and delivering the compressed air to the engine or engines as the case may be. In this way the difficulties encountered with the compressing pump attached to the engine are eliminated, and the advantages of the latest type of separate compressor are realized. This is somewhat analogous to the present marine practice of employing independent air pumps, rather than pumps directly connected to the engine.

Mr. E. J. Kunze In Professor Lucke's admirable paper he shows clearly that there are three disturbing influences ordinarily tending to act in such a manner as to cause variation in the combustion line and hence in the regulation of the gas engine, namely:

a Mixture variation,
b Explosive waves,
c Preignition.

Representing these by their initial letters, we may tabulate the points recorded in Professor Lucke's paper and check off these points as we find a possible solution of overcoming the difficulty involved.

M

a Pressure and temperature not constant,
b Suction of engine variable,
c Collection of charge in air chamber,
d Intermittence of flow,
e Vacuum effect,
f Proportion of air to gas,
g Dilution of charge by neutral gases.

E

a Method of ignition,
b Small impinging streams,
c Pockets in ducts and cylinder,
d Compression waves.

P

a Proper proportion of elements,
b Purging cylinder,
c Gas zones,
d Variation of mixture,
e Cooling inner cylinder wall,
f Cooling inlet passages,
g Inward projecting parts.

2 It would seem, from what has been said, that not only should the design of the gas engine receive more rational treatment and each part designed for the function which it is to exercise but also the gas generating apparatus should receive a like careful consideration.

3 Dr. Lucke's findings show that in a perfectly homogeneous gas it is possible to predict its ignition temperature if the proportions of H and O and CO and O are known; this leads us to the point that we

may by properly proportioning the relations of H and O and CO and O, obtain a gas which shall have as high a degree of ignition as is expedient, and this would indicate that our method of gas manufacture for power purposes must be modified and the process made more uniform. We should therefore have the amount of water vapor which passes through the bed of fuel regulated according to the amount of gas produced. The draft should likewise be regulated; hence a two cycle engine with an exhauster for maintaining draft on the producer would seem the most rational unit. The fuel bed should be of uniform thickness, hence we should have an automatic feed to the producer; the fuel bed should be of uniform texture in order to prevent air shoots and channels especially around the outer edges, hence the fuel bed should be constantly stirred. For bituminous coal as fuel the hydro-carbon gases should be permanently fixed, hence the producer should be of the down draft variety. We would then have a constant proportion of the proper elements, P, *a*.

4 If the gas is generated in a blast furnace, the gas ducts should be large and the gas enter the gas-holder in several directions. Propellers or other agitators should be used to keep the body of gas in the gas holder constantly in motion to prevent the localization of bodies of gas having various heat values.

5 If now a two cycle engine is used and the air and gas pumps which are required to compress the charge sufficiently to pass it into the cylinder are operated independently of the engine, we may have a *constant pressure of air and gas* M, *a*, entirely independent of the *suction of the engine*, M, *b*. This system can be very effectively adopted in multi-unit plants by concentrating the pump work to serve the outlying engine cylinders, one air and one gas pump serving several engine cylinders.

6 There should be no *collection of charge*, M, *c*, in the air chamber. Air alone should lie directly outside of the inlet valve, since any leakage of the valve may cause a back fire with disastrous effect. No charge should be made until it is passing into the cylinder; it should then be cut off by the action of the governor which should have as little mechanical work to do as possible. If the governor is of the inertia type, we are thus enabled to regulate the size of the charge at the latest point possible in a gas engine and here again we see an advantage of the two cycle over the four cycle in that the time between the cut off of the charge and explosion of the same may be reduced much more in the former than is possible in the latter.

7 If the ducts are so designed that the velocity of fluid is not

changed quickly and the charge is admitted into the cylinder without serious checking, we should not be troubled by the inertia of the gas and air, and *intermittence of flow* M, *d*, would be reduced to a minimum. Especially after leaving the mixing chamber should the charge be passed through as few turns as possible. Its course should be, to the greatest extent, unobstructed.

8 In the two cycle engine we are not troubled by the *effect of vacuum* M, *e*, on the flow of the charge.

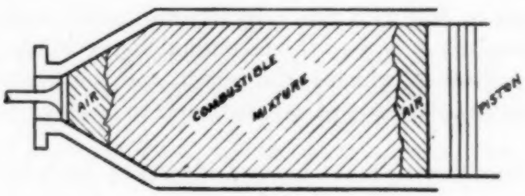

FIG 1.

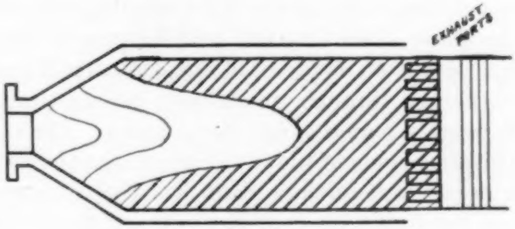

FIG 2.

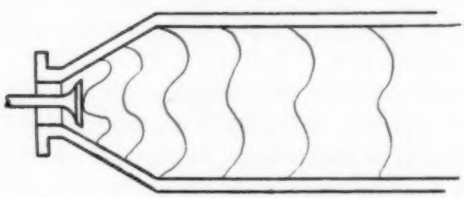

FIG. 3.

9 The gas having a constant heat value can then be thoroughly mixed with the *proper portion of air*, M, *f*, before passing into the cylinder and this charge made to lie between two strata of air, one stratum lying at the piston head, the other at the cylinder head. As the load decreases the charge of combustible mixture may be decreased proportionately and the charges of air proportionately increased so

that for varying loads we would have constant compression and at least for the most of the combustible charge, constant mixture, only the outer portion being materially mingled with the air strata.

10 Ignition, E, *a*, should be done from several points in order to insure certainty of ignition and hasten the flame proportion. It is well to place the igniters at different distances from the end of the cylinder so that the charge may ignite under its most favorable condition.

11 The most logical method of charge admission is at the end of the cylinder in line with the axis, but ordinarily such admission would puncture the core, *i.e.*, the incoming charge would follow the line of least resistance, which is the center, and the tendency would be to cause an annular body of exhaust gases to lie along the cylinder walls.

12 If we consider the plane of the orifice to be made up of a number of annular rings and assume the center core to have a given velocity, then the velocity of the points in the annular rings will be reduced as the area increases. We thus find points on our curve.

13 With a wave front as shown in Fig. 2 much of the comb mixture would be discharged through the exhaust ports before the cylinder had been thoroughly *purged of its exhaust* gases. The effect would be not only to displace some of the incoming charge and by the addition to the same of the heat of these gases and that of the cylinder wall which had not been properly cooled, to expand this incoming charge, but also to increase the initial temperature and hence reduce the amount of compression pressure which would otherwise be permitted.

14 If we more nearly flatten the wave front by using the inlet valve as a baffle plate, all these objections will be overcome; the peak of the wave is eliminated, P, *b*.

15 The shape of the modified wave shown can be verified by constructing a model of strips of wood about one-eighth inch high and of the shape of the contour of the cylinder, as shown with the inlet valve in opened position, placing these wood strips between glass or other transparent material and blowing smoke through the orifice. Successive puffing will show that the several bodies of smoke do not whirl around but fill the area completely and pass through the cyl nder without intermingling; another feature which goes to support the stratification theory.

16 By this means the cool scavenger air first admitted cools the inner surface of the cylinder wall most effectively and evenly and this directly before the charge enters the cylinder. Thus in this case the

heat stored up in the cylinder walls during the expansion of gases tends to keep the walls hot during the next expansion of charge, but the cooling of the inner portion of the walls permitted the admission of a maximum volume of charge and compressing same to a maximum degree of compression pressure before the heat in the walls had time to effect the charge.

17 If the charges are thus smoothly admitted into the cylinder, we will not be troubled with *impinging streams*, E, *b*, *pockets*, E, *c*, and *gas zones*, P, *c*.

18 The evil effect of the *compression wave*, E, *d*, will at least be reduced to a minimum if the mixture is uniform and the streaming of various bodies of gas having different heat values into one another, mixing as they do with difficulty, is avoided.

19 This phenomenon of failing to unite readily into a homogeneous mass, at least, partially supports the stratification theory when the latter is properly followed.

20 *Variation of mixture*, P, *d*, due to admission of exhaust gases, will not trouble us because we will have no exhaust gases left in the cylinder and we will have no need to *dilute*, M, *g*, our well proportioned homogeneous gas mixture with cooled exhaust gases.

21 Our cylinder wall will certainly be well cooled, P, *e*, and as our cylinder head may be of the most simple type (the frustum of a cone), it can be easily and uniformly cooled and the inlet passages may therefore be well cooled, P, *f*.

22 All *projecting pieces*, P, *g*, with the exception of the igniters may be avoided and even these may be at least partially water cooled.

MR. E. RATHBUN[1] As an explanation of the phenomena relating to explosion waves, so-called, I suggest that you may obtain an auxiliary explosion in the indicator piping, after the combustion in the engine cylinder. This is due to a combustible mixture remaining there and becoming ignited at a very high temperature and compression. Such an explosion would be in the nature of a blow upon the indicator spring.

2 On the card which I have copied on the blackboard, there is absolutely no indication of wave effect or excessive pressure in the indicator until after the expansion stroke has commenced. The stroke has progressed 20, possibly 30 degrees, before any effect is obtained, then a sudden impulse strikes the indicator. I find that these waves indicate vibration in equal times. This would seem to show that the effect is due to vibration of the indicator spring and connecting parts.

[1] Non-Member.

3 There may also be such a condition as vibration of the working fluid itself, but up to the present time I have seen no indication of it in the discussion; that is, all the indicators have been attached at some distance from the cylinder, and Professor Lucke showed also that in tests which did not show waves, the addition of a chamber to the rig itself would produce that effect. We have also in regular practice

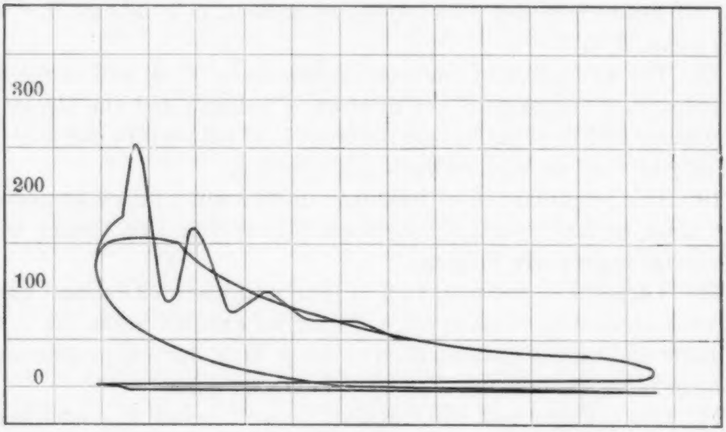

FIG. 1

been able to regulate these effects; that is, obtain a wave card by the regulation of a globe valve in the indicator pipe. If we take an indicator card with this valve wide open, we get wave effects, but as the valve is closed, the wave will gradually disappear until there will be no such indication. It would appear that the scavenging was insufficient to produce that effect.

Mr. S. A. Moss Why does Professor Lucke conclude that the waves shown in Fig. 7 to 11 inclusive, are not the indicator vibrations alluded to? I have seen many such waves on indicator cards and have always been inclined to assign them to indicator vibrations, since I know of no positive evidence that they truly represent variations of pressure in the cylinder. I call particular attention to the fact that the waves in Fig. 7 have greatest length near the center and least length near the ends of the stroke, indicating that they probably have the same time period. This seems to me to give a strong presumption that they are indicator vibrations only.